

THE
RUBBER RESEARCH INSTITUTE
OF
MALAYA

REPORT FOR THE PERIOD
SEPTEMBER 1945, TO DECEMBER 1948



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REPORTS OF DIVISIONS FOR THE PERIOD
SEPTEMBER 1945 TO DECEMBER 1948

CORRECTIONS

REPORT FOR THE PERIOD JANUARY 1941 TO AUGUST 1945

Page 100, line 4 : for "lateral" read "natural"
„ 102 5th line from bottom: for "clones" read "clone"

C. C. T. SHARP,
Acting Director.

KUALA LUMPUR
October 1950

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REPORT FOR THE PERIOD
SEPTEMBER 1945 TO DECEMBER 1948
SOILS DIVISION

SEPTEMBER-DECEMBER 1945

STAFF. Most of the Junior Staff had reported for duty by September. The three Senior Officers had been prisoners-of-war or internees but the Soils Chemist, Mr. Owen, spent a week in Kuala Lumpur on his way from Sumatra to England and was able to make a rapid survey of the condition of the laboratories, apparatus, chemicals etc. and to draw up a programme of work for the staff. Mr. K. S. Pillay, Assistant Chemist, was in charge of the Division.

CONDITION OF THE LABORATORIES. The only serious damage to the laboratory buildings was a leak in the roof through which the rain flooded the balance room every time there was a heavy storm. Apart from this only minor repairs were necessary. All benches and shelves had been removed from the main store room and the wooden partitions subdividing the larger rooms had been either removed or severely damaged by white ants. This greatly reduced the space available for the proper storage of apparatus and chemicals. Most of the gas, water and steam fittings were in fair order but many replacements of the electrical fittings were required.

The pot-culture house just outside the laboratories had disappeared completely. Stocks of apparatus and chemicals were badly depleted, particularly the commoner items of laboratory glassware and the ordinary mineral acids and alkalis. More delicate and specialised apparatus, such as balances, electric ovens and furnaces, pH meter, and absorptiometer were in need of repair, owing to misuse and neglect.

The most serious losses had occurred in laboratory and field records, and in the general correspondence files for estate experiments. Losses were due mainly to looting which occurred immediately after the British forces left Kuala Lumpur in January 1942, and again prior to the arrival of the Military Administration after the Japanese capitulation in August 1945.

All detailed growth measurements and yield records from estate experiments were missing, and many of the inspection reports were lost, although summaries for each experiment survived. Most of the Experiment Station measurement and yield records were complete but no records for the composting work done in 1940/41 could be found.

The records of work by Mr. Owen on phosphate problems in Malayan soils had fortunately been preserved and will be published, but no trace remains of the results of investigations of toxicity in peat soils.

REPORT FOR THE YEAR 1946

Changes in the staff of the Division were made during 1946. The Head of the Division returned to duty on 20th April, but until October was largely engaged in administering the Smallholders' Advisory Service; Mr. G. Owen, Soils Chemist, returned on 15th July, and Mr. L. R. Davidson, Advisory Officer, on 21st June. The latter was appointed from 1st October to the Smallholders' Advisory Service as the Officer-in-charge. Mr. Pillay, Assistant Soils Chemist, was on leave from 22nd August until the end of the year. At the end of 1941 twenty-one members of the Junior Staff were employed in the Division. Resignations and transfers reduced this number during 1946 to sixteen, of whom eight took the leave due to them for periods of five to eight months.

Complete orders for the replacement of chemicals and apparatus were sent to England early in the year, but no information regarding shipments had been received by December and it seemed unlikely that these orders would be fulfilled until the second half of 1947. In view of this threatened delay, supplementary orders for urgently needed items were sent to America, and the possibilities of obtaining supplies from India and Australia were investigated. It is hoped that some chemicals and apparatus will be received from these sources early in 1947. For these reasons little laboratory work could be undertaken and most of the time was devoted to the field experiments.

No major repair work has been carried out in the Division but many minor repairs have been effected.

I. Soil Survey Work

Much survives of the analytical data on soil samples and profiles, but little use can be made of these analyses because

they are referred to only by soil sample numbers. Without the field records giving the key to the sample numbers, identification of sampling sites and areas is impossible, and these records are missing.

Past experience and recollections of the various soil types will permit the selection of the sampling areas necessary for building up analytical records, with a minimum expenditure of unnecessary work. This work has not yet commenced, and until the necessary chemicals and apparatus have been received it is not intended to do more than collect a few profile samples from the better known soil types, together with suitable rock specimens.

II. Manuring of Hevea

In 1941 there were eighty-seven manuring experiments being carried out on mature rubber and on newly-planted and replanted young rubber. Forty-eight of these were visited in 1946 by senior officers to examine the present condition of the experiments and to decide which could be continued and what changes in the original treatments would be necessary. Girth measurements were taken by field assistants on fifty-one of the experiments during the course of the year.

TABLE I. *Summary of Field Experiments*

Type of Experiment	Number	Visited in 1946	Measured	Abandoned
(1) Manuring Experimental Planting	39	28	23	2
(2) Replanting ..	23	13	14	7
(3) Manuring Mature Trees ..	25	7	14	11
(4) Cover Crops ..	16	9	6	1

Principally because of damage to or loss of trees, and partly because of increasing age, some twenty experiments have been discontinued and many of the remainder will be continued in a modified form. The modifications are required chiefly because of the increased age of the trees and the commencement of tapping. Although a number of experimental areas on estates are once more in tapping or have been tapped for the first time, yield recording has not yet been undertaken

because there has been neither staff nor apparatus available to secure records of sufficient accuracy. The detailed examination of the measurements which have been obtained is not yet completed, but in the following sections some general comments are made on the results which are available. Before passing to these a few remarks are offered on the conditions prevailing in the majority of experimental areas immediately after the re-occupation.

The excessive growth of the natural covers has competed with the rubber trees and caused some retardation of growth. In most experiments the natural covers have been slashed and the jungle trees which had grown as tall as the rubber have been cut down at ground level. The most serious retardation of growth has taken place in the experiments planted in 1940 and 1941, and a few of these have been abandoned.

Lalang in amounts varying with local conditions has appeared in many of the experiments, principally in open spaces and near the boundaries where these adjoin land on which lalang is growing. Although the areas of lalang were mostly small they were large enough to affect the growth of the rubber trees and this will cause an interference with plot comparisons which the destruction of the lalang will not completely remove. The lalang has usually been dug out but the effects of soil disturbance and cultivation will need to be given due weight when comparing measurements between plots.

Untreated diseases and neglected drainage have also decreased the value of some of the experiments. Partial or complete removal of the rubber trees has so far been found in only four experiments.

The recording work of the field assistants has been greatly hampered by the difficulty of identifying the plot boundaries. Marking posts, particularly wooden ones, may have completely disappeared, and in areas planted on contours the identification of plot boundaries has not been straightforward. In 1941 galvanised iron wires marked the plot boundaries in the contoured experiments, but these pieces of loot were too tempting to survive the occupation years. The wires have not been replaced, but treatment letters and tree numbers, stencilled on the trees, give adequate means of identification.

MATURE RUBBER

The only experimental yield records which were obtained during 1946 came from Field 6 at the R.R.I. Experiment Station.

This field was regularly manured from the time of planting with stumps in 1928 until 1940, and it is intended to resume manuring in 1947. The manuring treatments and rates of application together with yields and girths in 1946, are given in Table II.

TABLE II. *Field 6, Manuring Experiment*

Treatment	Fertiliser	Amount per tree (lb.) 1940	Rate of yield 1946		Girths 1946	
			lb. per acre per annum	% of "A"	in cms at 60 in.	% of "A"
A	— ..	—	550	100	86	100
B	Cattle manure ..	56	652	119	91	106
C	Enpekay No. 1 ..	2½	685	125	94	109
D	Sulphate of Ammonia	2	605	110	85	99
E	Nicifos B ..	2	485	88	81	94
F	Sulphate of potash and Double Super (in equal propor- tion) ..	1¾	600	109	91	106

During most of the Japanese occupation Field 6 was in continuous tapping. Experimental yield recording was resumed early in 1946 when the tapping cuts were still on virgin bark, but by the end of the year renewed bark was being tapped for the first time.

Whilst the names "Enpekay No. 1" and "Nicifos B" are retained, these proprietary fertilisers are no longer available and have been replaced by mixtures of similar composition.

The yields recorded for the first two years of tapping, in 1935 and 1936, indicated a significant effect of manures on yield only for the "Enpekay" treatment. The latest records show that the cattle manure is also having an appreciable beneficial effect, and that the "Nicifos" treatment is causing a marked decrease in yield, thereby emphasizing the need for potash fertilisers on the very sandy soil of the flat areas at Sungei Buloh.

Girth measurements show approximately the same relative differences that are seen in the yield records, although, comparing the "percentage" columns, the range of difference is much narrower than for yields, and the yield improvement due to sulphate of ammonia has no corresponding girth increase. Whereas an accurate estimate of the economic benefits of

manuring in Field 6 would have to take into consideration the total quantity of fertilisers applied as well as the total yield obtained since the experiments started, an approximate estimate may be produced if two assumptions are made, namely that the present rate of yield can be maintained with biennial applications of fertiliser and that the additional yield brings in a profit of 20 cents a pound.

The type of "complete" fertiliser mixture used costs at present (April 1947) about \$160/- per ton, and since each application will be at the rate of 5 cwt. per acre, the total yearly cost including application will be about \$22.50 per acre. The difference in yield which this is expected to maintain, on the basis of the yields obtained in 1946, is about 135-lb. per acre, which is a 24.5 per cent improvement in yield over the unmanured treatment and gives an estimated additional income amounting to \$27/- per acre annually. Hence if the assumptions made are valid, a yearly profit of about \$4.50 per acre on a fertiliser expenditure of \$22.50 can be expected under the particular conditions prevailing in Field 6.

IMMATURE AREAS

The experiments which commenced as jungle plantings or replantings in the years 1937-1939 have in previous reports been referred to as "immature" areas. Although these experiments are no longer on immature rubber the heading is used here for convenience of reference.

(i) NEW CLEARINGS

At the time of recording measurements in 1946, the trees in most experiments were aged between seven and nine years, and during the war years, 1942-1945, annual girth increments had been between 6 cms and 7.5 cms. The average annual girth increments during the first years of growth, *i.e.* before 1942, had been 8 cms to 10 cms. Thus, there has been a slowing down of growth, which must be ascribed partly to the increasing age of the trees and partly to the unusual conditions, such as the failure to keep the cover crops under control which prevailed during the occupation.

The fertilisers applied before 1942 have not maintained their effect consistently in all experiments, and in general the residual effect has not been very pronounced. Thus in some experiments the original benefits from phosphate manuring are still to be seen in the better growth which has been maintained over the unmanured trees, although divergences of

TABLE III. *Effect of Manures on Growth of young Budded Rubber Trees in New Clearings*
Girths as a percentage of the unmanured controls

Estate	(1)	N	NK	NP	PK	NPK	P	K	Soil Type
A Johore	100	97.4	97.7	99.8	99.5	103	99.0	97.4	Inland Soil
B "	100	102	101	107	106	110	106	102	"
C Perak	100	98.1	96.7	97.9	99.8	95.8	98.4	97.4	"
D Johore	100	101	103	113	110	111	—	—	"
E Pahang	100	103	102	107	104	108	—	—	"
F Kedah	100	98.6	101	106	102	104	—	—	"
G Selangor	100	101	98.2	106	103	102	—	—	"
H Johore	100	99.8	100	113	108	116	—	—	"
Average	100	100.1	99.9	106.2	104	106.2	—	—	"
K Perak	100	102	100	101	97.3	99.2	100	97.6	Coastal Alluvium
L Selangor	100	97.0	96.0	99.5	98.5	99.2	—	—	"
M Negri Sembilan	N ₀	N ₁	N ₂	P ₀	P ₁	P ₂	K ₀	K ₁	K ₂
N	107	109	109	100	110	113	108	109	107
Trees destroyed during Japanese occupation									
O Perak	99.6	99.3	100	100	98.2	99.8	100	100	98.8

growth between manured and unmanured trees have only been appreciable where high levels of phosphate applications have been used. In other experiments, trees which have never been manured have grown better during the war years than the manured trees.

The growth figures given in Table III are for the same experiments as those given in the 1939 Annual Report, p.65, and the same general effects noticeable then are still apparent now, that is to say the main effect on growth of young buddings on inland soils has been produced by phosphates.

The alluvial soils (Experiments K, L, and O) have shown no response to fertilisers.

Phosphate manuring experiments

Of the six experiments previously reported in this series (Ann. Report, 1939, p.67) one has had to be abandoned because of the loss of trees suffered during the occupation period. Of the remainder the average girths recorded in 1946 still show the same increase that they showed in 1939 with increasing quantities of phosphates. The adverse effect of lime which was detected in 1939 has now disappeared.

TABLE IV. *Phosphate Manuring Experiments on Budded Trees*
Girth as a percentage of the unmanured control

Estate	Treatment							
	(1)	P ₁	P ₃	P ₅	P ₇	CaO	CaO P ₃	NP ₅ K
P N. Sembilan	100	107	105	110	111	99	107	109
R Johore ..	Destroyed by Japanese							
U ..	100	108	112	114	113	105	110	111
B ..	100	101	107	109	107	99.7	108	105
T ..	100	103	103	112	115	98.5	109	106
V ..	100	102	98.9	98.7	105	97.8	101	98.4
Average ..	100	104	105	109	110	99.0	107	106

In treatments P₁ to P₇ Superphosphate (18%) was given in amounts corresponding to the suffixes 1 to 7, and in December 1941, the quantity of Superphosphate applied in P₇ was 14 oz. per point. The other treatments gave lime (CaO), lime and superphosphate, and a complete mixture consisting of sulphate of ammonia, sulphate of potash and superphosphate (NP₅K).

Performances of different clones in new clearings

Comparisons are given between a number of clones in eighteen different experiments from all parts of Malaya, and variations are evident between the relative growth of different clones in different parts of the country. It cannot be stated whether these variations are due to climatic or to soil differences. The generally poorer growth of clone B.D.5 seems to be independent of soil conditions and is unaffected by normal applications of the main plant nutrients—nitrogen, phosphorus, and potassium. (Table V).

(ii) REPLANTING

The measurements recorded in 1946 indicate the same effects of manures on growth as have been previously reported, the principal response being to phosphatic fertilisers. Mineral rock phosphates have been as effective as the more expensive superphosphates and water-soluble types.

Applications of fertilisers in all replanting experiments ceased after 1941, and some serious effects on growth might have been expected from the omission of fertilisers during the ensuing five years. The rate of increase in girth has slowed-down slightly from 8 to 10 cms. annually for the first years of replanting to 6.5 to 8 cms. between 1941 to 1946, but the general health and appearance of the trees give no indication that lack of fertilisers has been of any serious consequence. The only exceptions are in areas replanted or budded in 1941, where the young plants suffered severely not only from lack of nutrients but also from lack of attention and from competition with the cover crops.

The indications from these observations are that manuring in the first three years of replanting is of greatest importance to the rubber plant, and that rates of fertiliser applications previously advocated have been more than adequate. The final effect of fertilisers must, however, be decided by tapping trees in experimental areas and determining the amount of rubber produced, and yield recording is to be commenced in 1947.

The success of replanting with an adequate manuring programme has now been effectively demonstrated in all parts of the country by the healthy replanted trees of high yield, which have survived the years of the Japanese occupation. Much has been said in company reports and written in the press regarding Malaya's need to speed up the replanting of her old rubber, and the economics of that advice cannot be

TABLE V. *Growth of Buddings in Manuring Experiments in New Clearings*
(Girths in cms. at 50" above union)

Estate	Approx age	P.B.86	P.B.186	Tj.1	Pil.B.84	Pil.D.65	B.D.5	G.1	Tj.16	P.B.25	Parent material of the soil
TH (Johore)	9.5	65.0	68.2	68.4	—	68.2	58.5	—	—	—	?
SX (Pahang)	9.0	59.2	58.4	63.5	59.2	—	49.3	—	—	—	?
PV (Kedah)	9.0	64.6	69.8	65.8	64.7	—	59.7	—	—	—	Lateritic shale
H (Johore)	8.3	—	54.0	57.2	—	—	—	53.1	—	—	Granite
L (Selangor)	8.25	55.2	—	—	64.1	—	—	62.2	—	—	Peaty loam
E (Pahang)	8.25	62.8	—	65.5	62.4	—	49.6	—	—	—	Shale
F (Kedah)	8.25	59.4	61.5	—	63.9	63.2	—	—	55.0	—	Quartzite
SV (Perak)	7.75	63.7	—	66.0	68.8	—	—	—	—	—	Quartzite sandstone
KS (Selangor)	7.75	54.3	—	64.2	—	—	—	—	—	—	Peat over clay
Y (Kedah)	7.6	62.0	—	61.3	—	—	—	—	—	—	Sandy quartzite
K (Dindings)	7.5	60.8	—	63.6	65.8	63.0	—	63.1	—	—	Heavy alluvial clay
SP (Perak)	7.25	60.9	—	63.9	—	—	—	—	—	—	Inland alluvium
C (Perak)	7.2	57.3	—	55.6	—	—	—	—	—	—	Inland alluvium
SB (Selangor)	7.1	—	—	54.8	49.0	—	—	—	—	58.0	?
D (Johore)	7.1	51.6	—	58.3	49.3	—	—	—	—	—	Granite
A (Johore)	6.7	—	—	60.8	57.1	—	—	—	—	—	Granite
SK (Johore)	6.5	49.4	—	56.1	48.5	—	—	—	—	—	?
O (Perak)	6.25	55.7	—	—	55.4	55.7	—	—	—	—	Coastal alluvial clay

discussed here. There is, however, for every estate an almost certain chance of technical success being achieved in replanting, and it is equally certain that the yield level to be obtained from the best selected planting material will far exceed any improved yield from old seedling rubber trees which could be produced by fertiliser applications. Furthermore, the importance of obtaining higher yields from younger replanted trees, which still have before them a long period during which they will remain in bearing, must be clear to the owners of all estates with considerable areas of old seedling trees of mediocre yielding capacity.

The main difficulty which is likely to hold up a number of replanting programmes is that of finance, for the cost of replanting by the conventional methods favoured before the war has increased with the rise in the cost of labour and if replanting is to be an economic as well as an agricultural success, it is essential that replanting procedure be modified and adapted to keep costs as low as possible.

It is suggested that the most promising procedures would include the following:

- (1) utilise as far as possible existing plants as ground cover and so reduce the cost of establishing and maintaining legumes;
- (2) reduce the rate of application of manures as the trees approach maturity;
- (3) wherever the lie of the land makes it possible dig or cultivate by machinery;
- (4) remove the old stand of trees either mechanically or by poisoning.

The largest economies are likely to be made under items 3 and 4 since they will include operations such as drain digging, road making, terracing, holing, cover crop removal and soil cultivation. Whether it is more economical to dig out the old trees mechanically or to poison them depends largely on the amount of root disease present in the old stand; if the incidence of disease in the new stand should be heavy it is possible that mechanical clearing in spite of its higher initial cost may prove cheaper in the end.

FERTILISER SUPPLIES

A world control of fertilisers was maintained throughout most of 1946 by the International Emergency Food Committee in Washington, which apportioned supplies of the main

fertilisers (nitrogen, phosphoric acid, and potash) to consuming countries. The major portion of the allocation for Malaya was intended for food production and it was only towards the end of the year that a small amount became available for other agricultural crops.

During the war years a greatly increased world demand for nitrogenous fertilisers was experienced, and in 1945/46 world demands were much in excess of supplies, the total production then being 1,878,000 tons (metric) compared with 2,382,000 tons in 1938/39. This deficit was principally caused by the fall in production in European countries and in Japan.

The prices of fertilisers in Malaya have only increased by about fifty to seventy per cent over 1941 prices, but in relation to prices in the United Kingdom they remain high.

The total imports of sulphate of ammonia from Great Britain into Malaya were 8,132 tons in 1946 compared with 24,873 tons in 1938.

Thus, in the first post-war year in Malaya, both scarcity and price have discouraged an extensive use of fertilisers on rubber plantations. The estates have also been more concerned with the major problems of re-organisation and re-construction than with manuring.

III. Cover Crops

The object of these experiments was to compare the effect of different cover crops on the growth of young rubber. During the war years big changes took place in the flora in the different treatments and when inspected in 1946 all the experiments were found to consist almost entirely of natural covers with certain species tending to predominate and only traces remained of the leguminous covers originally planted. It was therefore no longer possible to carry out the experiments as originally intended.

In two of the experiments inspected the losses of trees have been so heavy that they no longer have any experimental value. The remaining ten will be used for fertiliser experiments.

LALANG CONTROL BY ARSENICAL SPRAYS

After the reoccupation it was found that lalang had encroached in varying amounts on most estates and its eradication was a problem of first importance. The control

of lalang by spraying with sodium arsenite and other weed killers has been described by J. L. Greig, (*Malayan Agricultural Journal*, 1937), and further trials with arsenic sprays for lalang control were commenced in January at the Experiment Station by the Acting Director (Mr. Sharp) and the Assistant Pathologist (Mr. John). These trials came under Soils Division supervision from April onwards, and in August further experiments were started with sodium arsenite which by then had become available in sufficient quantities.

The results of this work indicated that lalang under rubber trees could be eradicated by spraying followed by hand-pulling or forking, and that the cost should be appreciably below \$100/- per acre, each spraying round costing about \$7/- per acre. This figure compares favourably with the removal of lalang by digging or forking, combined with hand eradication of the roots, at a cost of \$200/- or more per acre.

Poisoning and chipping are similar in that by destroying the above-ground green portion of the plant they gradually weaken and kill the root system. The chemical used for poisoning may also penetrate the surface of the soil and kill the below-ground portions of the plant.

Changkolling and forking cause considerable soil disturbance which may produce serious losses by erosion and, in areas where rubber trees are growing, may damage the tree roots. With chipping, soil disturbance and root damage are much less, and with poisoning, are nil except for that produced by the final round of forking.

The cost of chipping rounds is higher than spraying and chipping scatters the lalang unevenly, whereas if it is sprayed the lalang dies *in situ* leaving a mat of dead blades which helps to smother the new shoots. For this reason it is undesirable to do preliminary slashing before spraying except for path making.

The best results from spraying or poisoning are achieved when the weather is dry, and much of the lack of success where sprays have been used is due to rain. This automatically limits the periods of most successful spraying to certain months of the year, although moderate success can be attained in rainy weather.

Of chemical poisons at present available in Malaya, sodium arsenite seems to be the most effective, although there are certain disadvantages connected with its use. It is extremely poisonous to both men and animals, and it may cause skin

dermatitis to the workers using it if the bare parts of the body are not protected.

DAMAGE TO SOIL AND RUBBER TREES BY ARSENIC

Sodium arsenite will kill all common weeds as well as lalang, and it has been used extensively in America for weed control and soil sterilisation. After the initial sprayings at the R.R.I. Experiment Station, surface weeds have not reappeared for about six to twelve months. Whilst repeated sprayings will prevent all weed growth, American experience has been that the use of arsenicals for weed control in deciduous orchards has no injurious effects on the soils or on the trees. On the other hand, where arsenic is applied as a soil sterilant in orchards there is danger of damage occurring to the tree crop, which is understandable because the chemical is injected into or applied directly on to the soil. In Hawaii sodium arsenite sprays have been used extensively and repeatedly for weed control with little or no toxic action on the soil and the lack of toxicity is ascribed to (1) low rates of application of the arsenic, (2) high rainfall and (3) the highly ferruginous nature of the soil which tends to fix large quantities of arsenic in a form in which it is unavailable to plants.

In California the amounts of arsenic injected into the soil for the purpose of sterilisation were of the order of twice to twenty times the total quantities applied by ten sprayings with $2\frac{1}{2}$ per cent. sodium arsenite, and the effectiveness of the dosages, or degree of toxicity, was measured by the growth of fresh indicator plants thirty days after planting in test pots in soils moistened with the herbicide solution. In comparing these applications with those used for lalang spraying in Malaya it must be remembered that most Malayan soils have a high content of iron in the form of oxides and hydrated oxides which will be responsible for a rapid fixation of soluble arsenite when it reaches the soil, and also that the high rainfall in Malaya will leach and wash away an appreciable part of the applied sodium arsenite. Furthermore, dosages which are toxic to small indicator plants may not be toxic to large trees.

So far as we know, damage to rubber trees arising from toxic soil conditions produced by sodium arsenite spraying has not been reported and if any serious harm to the feeding roots of mature rubber trees follows from sodium arsenite spraying an immediate effect would be expected on the foliage of the tree.

Toxic effects are most likely to occur where excessively heavy sprayings have been applied on light sandy soils carrying young plants up to one or two years of age. To test the effect of spraying on young trees a nursery of rubber seedlings, about twelve months old, growing on very sandy soil at the R.R.I. Experiment Station was given eight sprayings with $2\frac{1}{2}$ per cent. sodium arsenite solution. All leaves were removed from the ground before commencing to spray, and the spray was directed on to the ground. Early observations showed that the smaller and weaker seedlings developed yellow and brown leaves after the third spraying.

About six months after the first spraying was given, the following figures were obtained:—

Circumference of plants	Dead	Died back	Not Affected
Plants less than $2\frac{1}{2}$ in. ..	41%	32%	27%
Plants over $2\frac{1}{2}$ in. ..	—	16%	84%

The plants which are listed as “Died back” were all putting out new shoots.

Damage to the bark of trees of Tj.1, P.B.86 and Pil.B.84 has been observed six to twelve months after sprays were applied to lalang in an experimental field at the R.R.I. Experiment Station, the trees having been planted as stumps in 1941. The nature of the damage varied: in some cases the bark was killed and the wood exposed, while in others the damage was slight and the only visible effect was a “flaking” and peeling of the outer bark. The largest wounds exposed the wood for a length of eight to ten inches in a narrow pointed slit of two to three inches width at its widest point, and no permanent damage seems to have resulted, although complete callusing of the exposed wood may take some time.

A count of the damaged trees indicates that the numbers seriously affected vary from $2\frac{1}{2}$ per cent. to 15 per cent. in blocks of clones, and, as would be expected, the greater amount of damage occurred in the area of poorer foliage development where the lalang was densest and growing close to the rubber trees.

The evidence at present indicates that the wounding of the bark has been caused by direct contact with the sodium arsenite spray which was applied to lalang growing close to

the rubber trees. Further investigations of this type of damage are being made, to find out how many times the bark must be sprayed before damage will be caused.

It is clear that the careless use of sodium arsenite sprays may easily damage the bark of rubber trees, and that young seedlings may quickly be killed by the spray. Proper precautions therefore must be observed in areas of standing rubber when using sodium arsenite sprays to prevent the poison touching the tree stems or foliage, and the spray should not be used near very young plants.

OTHER METHODS OF CONTROLLING LALANG

There are a number of disadvantages in the use of sodium arsenite sprays for lalang eradication: for example it is highly poisonous to men and animals, a large amount of water is required, wet weather may adversely affect the results and manual spraying is very slow.

For these reasons other methods of eradication will be tried including the following:

- (a) Spraying with tractor-drawn power-operated sprayers;
- (b) Control by improving the foliage of rubber trees and shading out the lalang;
- (c) Artificial shading with strips of paper;
- (d) Competition with vigorously-growing creepers;
- (e) Spraying with growth-promoting substances;
- (f) Mechanical ploughing and cultivation.

IV. Soil Management

Experiments in this category, in which the effects of different methods of preparing jungle land were being studied, show that the growth of rubber plants has not been materially affected by the treatment of the jungle, i.e. growth in a "no-burn" clearing has been as good as where a normal burn has taken place.

The different types of covers used in the experiments have all merged into one more or less uniform mixture of indigenous covers, and in future these areas are to be used for further manuring experiments.

MECHANISED OPERATIONS FOR CULTIVATION, CLEARING AND REPLANTING ON ESTATES

Up to 1941, machines had hardly appeared in cultivation operations on rubber estates in Malaya, although in one or two instances some felling of jungle and of rubber had been done mechanically by contractors, and in 1945/46 the immediate tasks of re-occupation focussed attention and efforts on organisation of labour and supplies rather than on new methods of operation. But during 1946, when it was realised that the shortage of labour and the high rates of pay were likely to persist, it became clear that the use of machines as a means of reducing costs must be considered.

There is very little information available on the performance of machines under Malayan conditions; in fact, the general-purposes machine—the tractor with bulldozer attachment—is the only one which has been used to any extent since the war, and its selection has been due solely to the immediate availability of spare machines from military stocks. A careful examination of the operating costs scheduled by the manufacturers suggests that under ideal working conditions, that is to say perfect trouble-free running; maximum working hours per day without interruptions caused by unsuitable weather; straightforward working conditions; first-class machine operators, etc., appreciable economies over hand labour costs should be achieved in a number of important estate operations, such as felling and clearing jungle areas, felling trees for replanting, draining and cultivation work on belukar, lalang and covers. It remains to be demonstrated under local conditions to what extent such advertised costs can be approached in practice.

The initial cost of tractors of the caterpillar type is heavy, and to obtain the greatest economy full-time employment of the machines is necessary. In considering this, several methods of owning and operating machines are possible—

- (1) by single companies,
- (2) by groups of companies, or
- (3) by contracting firms.

The choice of method will be decided by the acreage and by the compactness of areas over which operations are to be done.

It seems most probable that in the early stages mechanised operations on rubber estates will be carried out by engineering firms under contract. The chief reasons for this view are:—

(1) that estates, or even groups of estates, will not have sufficiently large areas requiring the use of machines to justify individual estate ownership of the machines, and that even allowing for the high costs of transporting machines about the country, it will still be more profitable to have mechanised operations done by firms of contractors;

(2) that the necessary trained engineering staff, operators and maintenance facilities will be more effectively provided by contracting firms than by the average estate organisation;

(3) that shortage of equipment will necessarily at first restrict operations to a few firms.

The main agricultural criticism of the use of machines for cultivation and felling operations is that excessive soil erosion may be produced. But provided suitable land which is not too hilly is selected, and a well-trained and carefully instructed machine-operator is employed, soil disturbance need not be dangerously great in such operations as felling and stumping trees, piling timber and clearing covers. Ploughing and harrowing operations in standing rubber are not recommended because of the large amount of root damage which might be done. On the other hand, mechanical stumping as opposed to tree poisoning, for removing old trees during replanting operations, has the advantage of removing diseased roots which may otherwise cause infection of the new stand of trees. One advantage of mechanisation in field work is the greater speed, compared with using manual labour, at which work can be done. The particular value of this in replanting is in reducing the time required for felling the old stand and consequently lengthening the period during which it can be tapped.

Thus, the value of mechanised field operations on rubber estates remains to be proved and at present the Institute is concerned with collecting reliable information concerning any mechanised work which is being done on rubber estates in Malaya. During 1947 it is hoped to commence experimental work on the eradication and control of lalang by ploughing and harrowing operations in land not carrying rubber trees.

V. Laboratory and Pot-Culture Work

Because of the lack of chemicals and apparatus very little laboratory work was done in 1946.

VI. Advisory Work

A considerable amount of correspondence was received, and despatched, (427 letters received and 590 despatched), and the matters receiving most attention were concerned with weed killers and lalang eradication, and with experimental areas on estates.

Visits to estates numbered 57, of which 18 were for advisory purposes, and 17 visits to the Experiment Station were made. Interviews given at the Institute to visitors and enquirers amounted to 90.

No lectures to planting associations and societies were given.

REPORT FOR THE YEAR 1947

STAFF

The Head of the Division was absent on long leave from the beginning of November 1947, and the only remaining Senior Officer, Mr. Owen, was in charge of the Division for the last two months of the year.

In June, the Assistant Soils Chemist, Mr. K. S. Pillay, who had been on the staff of the Division since 1929, had unfortunately to resign his appointment owing to ill-health, and the vacancy thus created was not filled.

No new appointments were made to the Junior Staff, and eight field and laboratory assistants were absent on long leave for periods varying from two to five months.

I. Soil Survey Work

Owing to shortage of chemicals and apparatus very little laboratory work was carried out. Some field work was done and about twenty profiles were sampled. With members of the Geological Survey Department some preliminary discussions were held on rock identification and on co-operative field work, but it was not possible to arrange any joint field work.

II. Manuring of Hevea

The work of inspecting experimental areas continued and 53 were visited. Annual growth measurements were recorded in 73 manuring experiments, and it was possible towards the end of the year to start recording the yields of six. Fertiliser supplies became more readily available, and in ten experiments the application of fertilisers was resumed for the first time since the war. At the R.R.I. Experiment Station the manuring of Field 6 was resumed in continuation of the regular manuring carried out from 1929 to 1940. In Field 31, R.R.I. Experiment Station, the first post-war application of fertilisers was made, and in August, tapping commenced on a full-spiral cut (S/1, d/4, 100%). The yields from both these experiments were recorded.

EFFECT OF FERTILISERS ON GROWTH

The experiments planted in 1937 to 1939 must now be described as young mature areas, and over thirty were in tapping by the end of 1947. A detailed analysis of the post-war girths and increments is to be made as soon as all the records have been collected. It is possible to give here the general trend of the results so far examined.

In eleven experiments the following effects of fertilisers on growth have been shown, up to and including the first post-war measurements:—

<i>Nitrogen effect</i> :—	Significant and positive	1 experiment	
	Slightly positive, not proven	.. 1	„
	Nil	.. 6	experiments
	Nitrogen treatment not included	.. 3	„
<i>Phosphate effect</i> :—	Highly significant and positive	.. 8	„
	No effect (alluvial soils)	3	„
<i>Potash effect</i> :—	No effect	.. 7	„
	Slightly negative and significant	.. 1	experiment
	Potash treatment not included	.. 3	experiments

On inland soils phosphate manuring has been most beneficial but nitrogen and potash have not produced any marked benefits. On alluvial soils fertilisers have been without

effect on growth, although on one coastal clay type a slightly negative result was obtained with potash.

The post-war girth increments show no residual influences of the pre-war fertiliser applications, and there is a tendency for the more backward unmanured plots to catch up the better grown plots where there have been fertiliser responses.

The same conclusions apply to four replanting experiments for which the girth records are available.

The clones used in the above experiments show some variation of growth, depending on soil type. On inland soils, clone Tj.1 has usually shown the most vigorous growth, but the less well developed clones, Pil. B.84 and P.B.86, are now showing a slightly better growth rate and appear to be catching up in girth. In an area of peaty-clay soil, clone G.1 is the best grown clone and continues to grow faster than the others.

III. Cover Crops

The main cover crop problem on estates continued to be that of controlling lalang, but whereas lalang which had appeared in rubber areas where overhead shade was rapidly closing in could be fairly easily controlled by spraying with sodium arsenite, its control and eradication in more open situations was more difficult.

Tests were made at the R.R.I. Experiment Station on sheet lalang in the open to ascertain whether spraying alone or in combination with hand cultivation would eradicate lalang and permit planting with rubber to follow. Several strengths of sodium arsenite were used, and planting points were prepared in cleared strips or circles.

It was found that even after eight spraying rounds, further treatment of the lalang by chipping or changkolling was required before normal weeding could be adopted. Rubber seedlings were found to grow normally in cleared strips or circles when planted after the completion of eight sprayings, and showed no signs that residual harmful effects remained in the sandy loam soil from the arsenical spray.

The practical conclusions which were drawn were that under favourable conditions a minimum of four sprayings with sodium arsenite on sheet lalang are needed after which rubber may be planted in changkollled strips. The remaining lalang requires careful control by 'spot' spraying and 'spot' changkolling

before it is eradicated. Under the most favourable conditions $2\frac{1}{2}$ per cent. solutions of sodium arsenite are more than optimum strength. The mat of dead lalang plays an important part in smothering and controlling new growths, and spraying should not be preceded by slashing or burning.

It was found that when rubber had been planted in cleared circles any subsequent spraying of the surrounding lalang was likely to cause damage. The spray liquid must be kept off the young rubber plants and a simple and effective guard can be made from ordinary sacking stretched on light bamboo poles.

Another chemical method of controlling lalang was tried with a plant growth regulating substance, isopropylphenylcarbamate, which has been successfully used in Europe specifically against grasses. This chemical was without any appreciable effect on lalang.

Attempts were made to smother lalang by artificial shade. The shade was produced by strips of tough sisal paper impregnated with bitumen, which were laid on lalang that had received three sprayings with sodium arsenite. Shading up to three months only suppressed the lalang, which rapidly regenerated once the sisal paper was removed.

Efforts to establish covers (*Mikania scandens*, *Pueraria javanica*, *Mimosa pudica*) in sheet lalang, with the object of replacing the lalang by another cover, were without success.

Towards the end of the year other types of weedicides became available and tests with the new substances were planned for 1948.

A report was received from an estate that old stocks of sulphur dust had been applied to lalang and that the grass had been effectively killed. Very large amounts were applied, and the cost of the treatment was quite uneconomical being estimated at several hundred dollars per acre.

No investigations were made on the effectiveness of tractor-drawn ploughs, harrows or other mechanical methods of eradicating lalang.

IV. Soil Management

MECHANISED FIELD OPERATIONS ON ESTATES

Considerable interest continued to be shown by rubber planters in the possibilities of mechanised clearing and replanting operations and control of covers. A number of engineering

firms in Singapore and Kuala Lumpur undertook estate field work, principally the felling and stacking of old rubber trees prior to replanting, and extensive developments with heavy tractor units were being considered. Whenever possible inspections of such work were made, and details of operating costs were obtained.

No investigational work was undertaken because no senior officer had sufficient time to plan the work and to give it the detailed supervision which field operations require. Attempts to hire equipment for lalang eradication trials at the R.R.I. Experiment Station, using tractor-drawn ploughs, harrows, etc., were unsuccessful.

The few observations which were possible during 1947 showed that for felling and uprooting and stacking old rubber trees, machines can be used very successfully and at lower costs than by using hand labour. There has not, however, been sufficient replanting done mechanically to study carefully all the different procedures which might be used, and the techniques adopted will no doubt be improved as experience is obtained.

The other main operation for which mechanical methods might well be applied is lalang eradication in open areas. Until careful comparative trials have been made which produce accurate records little can be said about such work, except that the proper sequence of operations with the appropriate implements should be able to compete favourably in cost with hand changkolling.

V. Laboratory Work

GENERAL

The first supplies of apparatus and chemicals ordered early in 1946 did not begin to arrive until the second half of the year, and consequently little laboratory work was possible during the first six months.

The assembling and checking of new and renovated items of apparatus (*e.g.* Beckmann pH meter, electric ovens and furnaces, Spekker absorptiometer) were carefully supervised, and when this equipment was finally installed during the third quarter of the year, a considerable increase in the output of laboratory analytical work took place. Chemicals were still arriving slowly, and the absence of certain reagents prevented the maximum output being attained.

Methods of soil analysis were closely studied, and discussions were held with the Department of Agriculture regarding the standardisation of routine procedures.

Analyses of serum residues from concentrated latex confirmed figures obtained in 1939. The waste serum contains an appreciable amount of nitrogen as ammonia, and when applied at the rate of 12 to 15 gallons per tree, will be equivalent to a normal application of sulphate of ammonia.

Routine analytical work was principally concerned with the analysis of soil samples both for advisory purposes and for the general examination of established soil types. Rubber leaves, fertilisers and other miscellaneous samples were analysed:—

Soils	..	..	..	143 samples.
Fertilisers	..	..	..	16 „
Guanos, cow-dung		..	..	6 „
Plants	..	..	..	11 „
Serum liquid	..	..	..	4 „
Identification	..	..	..	4 „
Miscellaneous	..	..	..	13 „

RESEARCH

Towards the close of the year, when chemicals and laboratory equipment began to arrive, a start was made on the determination of available plant nutrients in local soils.

Standard chemical methods for assessing available plant foods, particularly available phosphate, have proved to be of limited value when applied to Malayan soils. Methods were studied which utilise the analysis of indicator plants instead of acid extracted leachates, for the determination of available plant nutrients. A modification of the well-known Neubauer method was employed since it combined relative simplicity with quickness. Preliminary work was done on the use of padi seedlings as the indicator or extracting plants, and comparisons were made between different varieties and varying lengths of growing periods.

The indications are that padi seedlings can be used satisfactorily and the investigation will be continued, particularly to ascertain the applicability of the method to research on soil fertility and fertiliser usage problems.

VI. Advisory Work

CORRESPONDENCE AND VISITS TO ESTATES

The main subjects of advisory correspondence and reports were the manuring of backward young rubber trees, and the treatment and control of covers in neglected immature areas, with lalang eradication as the chief point of interest. During the latter half of the year replanting and mechanised methods of cultivation were additional matters upon which advice was sought.

The numbers of letters, visits paid etc. are given below:—

Visits to estates	— advisory	..	67
	— experimental	..	53
Visits to R.R.I. Experiment Station		..	25
Correspondence	— advisory	..	454
	— experimental	..	398
Interviews at R.R.I.	..	..	146
Lectures	..	..	2

PUBLICATIONS

In August two papers by G. Owen on “Retention of Phosphates in Malayan Soils” were published as Communication 262 to Vol. 12 of the *Journal of the Rubber Research Institute*. The experimental and laboratory work had been done in 1941 and the survival of the data through the occupation period made possible the production of the two papers.

In November, an advisory leaflet, S/AL.9(47) on the control of lalang with sodium arsenite, was issued, and also circular No. 27 on “Methods of application of Fertilisers.”

LECTURES

Two lectures were given to branches of the Incorporated Society of Planters:—

in August, “Soils—Current thoughts on their treatment” by G. Owen, at Taiping, to the Taiping Branch;

in September, “Weed Control”, by C. G. Akhurst, at Kulim, to the South Kedah Branch.

REPORT FOR THE YEAR 1948

STAFF

The Division remained very much under-staffed during most of the year, and for the period January to July, when the Head of the Division was on long leave, there was only one Senior Officer (Mr. G. Owen) on duty. Mr. W. H. Williams, M.A., B.Sc. (Aberdeen) arrived on 9th December and took up the post of Advisory Officer.

I. Soil Survey

Field and laboratory work continued on soil profiles, of which thirty were examined and sampled. A preliminary examination has been made of the field observations and analytical results so far available, and certain broad distinctions can be observed between soils, using mineral nutrient figures as a basis of comparison.

A broad classification of soils into three main categories, based on general properties and characteristics, gives (1) normal inland soils, (2) fertile inland soils, and (3) coastal alluvial soils. Easily distinguishable by colour and structure from other inland soils, the fertile inland soils form a very small group which are derived from doleritic and basaltic parent materials and from limestone. The normal inland soils are a large group derived from granite, shales, schists, quartzite, sandstones, etc., and are typical of Malayan soils generally. Insufficient analytical data are at present available for critical comparison of the different soil series within this group.

Available or readily soluble phosphate, as determined by the standard chemical method (Truog) is low for all the Malayan soil types which have been examined, and, with three exceptions, the values all fall below 10 p.p.m. (parts per million). The three exceptions are found amongst the coastal alluvial soils for which the mean available phosphate, in surface horizons, is 9 p.p.m. For normal inland soils the mean value is 5 p.p.m. Alluvial soils seldom show responses to phosphate manuring, and although the above difference is small, it appears to be of some significance.

Although the phosphate extracted from local soils by the Truog method may not represent the actual amounts available to plants, the consistently higher phosphate figures obtained for the non-responsive soils, in comparison with the lower

phosphate content measured in other soils, indicate a limit of adequacy which in spite of its low level may be generally applicable for distinguishing soils on a phosphate fertility basis.

Total phosphate (HCl extract) varies considerably over all types of soil, and does not appear to be correlated with available phosphate. The values for all normal inland soils, and for most coastal alluvial soils, are less than 1,000 p.p.m., but for fertile inland soils, the mean total phosphate is appreciably higher. For one soil type derived from a basic lava, total phosphate values were over 2,000 p.p.m. in all horizons except the lowest, but the available phosphate did not exceed 4 p.p.m. The available phosphate in the fertile inland soils group has one of the lowest mean values, and, considered with their high total phosphate, shows a high degree of fixation of phosphate.

Differences between inland and coastal alluvial soils are fairly clearly marked when data for exchangeable potash are examined. The values for coastal alluvial soils are usually over 100 p.p.m., whereas normal inland soils exceed this amount only occasionally.

The values for total potash (HCl extract) are extremely variable, but again differentiate inland from coastal soils. All coastal alluvial soils, except the peaty soils, give high values, ranging from 1,000 p.p.m. to 3,000 p.p.m., but the majority of inland soils contain less than 1,000 p.p.m. Some inland soils, however, show high total potash figures, indicating an abundant reserve, although not necessarily readily available. Inland soils derived from schists and shales have shown as much as 8,000 p.p.m. total potash.

There is, on the basis of exchangeable and total potash values, a broad classification of soils into inland and coastal alluvial groups, but within each group there is no apparent correlation between the potash contents and the different soil types.

A summary of the data for mineral nutrients in surface soils is given in Table VI.

If the mineral nutrients, as determined by chemical analysis, in different soils are considered in relation to the growth of rubber trees and their response to varying fertiliser treatment on these soils, it becomes apparent that no simple relationship exists between tree growth and the mineral nutrient status of the soil, and that both total and available

nutrients as well as numerous other factors must be considered when assessing the "fertility" of a soil by soil analysis.

During the last part of the year, standard colour books (Munsell) as used by the United States Soil Survey Department were obtained and used for standardising colour descriptions in the field examination of soil profiles.

II. Manuring of Hevea

Growth measurements were taken in 71 experiments, and by the end of the year yield records were being received from eight areas. In fourteen experiments the first post-war application of fertilisers was made. Visits to estate experimental areas were on a reduced scale owing to lack of Senior Staff. The Statistician examined and made statistical analyses of the experimental records from time to time.

Growth measurements from experimental areas of young mature rubber have not indicated any effect on the present growth rate due to the pre-war manuring, and where post-war fertiliser applications have been made (in 1947) no change in growth rate has yet been produced. The growth improvements by fertilisers applied during the years of early growth, as reported previously, have been principally due to phosphate manuring, and the girths measured in 1948 confirm this. Nitrogen fertilisers have a much smaller but positive effect on growth, and potash has little or no effect. These effects have been produced on normal inland soils, but on coastal alluvial soils all types of fertilisers have failed to influence growth.

Whilst the magnitude of the phosphate response varies between estates, differences due to varying levels of phosphate manuring have been only slight.

A summary Table VII of the mean girths and increments for several clones, according to age, shows the rapid drop in girthing which takes place when trees mature and come into tapping.

Experiments were in progress to ascertain the effect on growth of different methods of applying fertilisers to immature and mature rubber. Growth measurements have not yet given any indication whether 'surface application' or 'pocket placement' is more suitable.

At the Experiment Station, in the manuring experiment in Field 6 weekly counts were made in each of the thirty-six

TABLE VII. *Mean girths, in inches, at 60 inches, for 1948*

* Year	P.B. 86	Tj. 1	Pil. B.84	Other Clones	Mean
1937	25.6 (4)	28.7 (3)	27.25 (3)	25.05 (4)	25.7 (3)
1938	24.8 (8)	25.6 (9)	25.1 (5)	23.7 (4)	24.95 (10)
1939	24.1 (10)	25.8 (7)	24.6 (11)	25.5 (4)	24.85 (14)
1940	22.2 (1)	25.55 (2)	22.5 (3)		23.05 (5)
Average 1937 to 1940	24.5 (23)	26.05 (21)	24.8 (22)	24.7 (12)	

* The year shown in the first column gives the date of budding or, for budded stumps, the date of planting.

Mean increments, in inches, for 1946/47/48

	P.B. 86		Tj. 1		Pil. B.84		Other clones		Mean	
	1946/47	1947/48	1946/47	1947/48	1946/47	1947/48	1946/47	1947/48	1946/47	1947/48
1937	1.02 (3)	.71 (3)	1.13 (2)	.63 (2)	.70 (3)	.87 (2)	.95 (3)	.85 (3)	.93 (3)	.74 (3)
1938	1.25 (5)	.66 (8)	1.03 (4)	.76 (9)	1.10 (2)	.58 (5)	1.15 (1)	.77 (4)	1.19 (5)	.74 (10)
1939	1.22 (7)	1.04 (10)	1.39 (3)	.91 (7)	1.38 (7)	1.15 (11)	1.26 (2)	.94 (4)	1.29 (7)	1.07 (13)
1940	1.85 (1)	.98 (1)	1.94 (2)	1.04 (2)	1.76 (3)	1.37 (3)	.95 (1)	1.53 (2)	1.67 (3)	1.39 (5)
Average 1937 to 1940	1.23 (16)	.85 (22)	1.22 (11)	.83 (20)	1.26 (15)	1.02 (21)	1.05 (7)	.87 (13)	1.26 (18)	.98 (31)

Most of the areas from which the above measurements were taken had been manured by 1948 and were in tapping.

plots of manuring treatments of the rubber seed which fell during a five-weeks period from the end of September to the end of October. The numbers of seed obtained showed that trees receiving phosphate manures were producing most seed. As the seed counts were made over only part of the seeding season, a more complete record is to be obtained next year.

Bark thickness measurements were also recorded on trees in Field 6, and showed that both virgin bark and renewed bark had been similarly affected by the fertiliser treatments used on the very sandy soil of this manuring experiment. Nitrogen had been without effect; potash, in the presence of phosphate, had been slightly beneficial, and phosphate, in the absence of potash, had produced a slightly thinner bark.

A series of manuring experiments on mature seedling rubber were commenced in 1937, and although detailed records and history are not available it has been possible to combine summaries of pre-war girth measurements with those taken since the war. The measurements relate to four estates in south Malaya on average inland soils. Fertilisers were applied annually from 1937 to 1940, and the trees were then around the age of fifteen years. Although the post-war measurements were taken at a different height from the pre-war ones, and were probably taken on a slightly different sample of trees, the girth increments show certain responses. Up to 1941, no definite responses to fertilisers occurred, although nitrogen was beginning to show some benefits. Since 1941, and with no further applications of fertilisers, there has been a fairly definite response to phosphate manuring in the presence of nitrogen. Potash has been without effect on girth, although the tendency is for it to have retarded growth.

Data from experimental areas relating to the influence of fertilisers on the yield of rubber trees are being accumulated, but are insufficient at present to show any very definite results. Records for at least one or two years will be required before effective comparisons between different fertilisers can be made.

The few records available from manuring experiments do show very considerable differences of yield between the different clones in any one experiment, with the better clones yielding from 150 per cent. to 250 per cent. more than the lower yielders. No interaction effect between fertilisers and clones has been detected.

The yields obtained from Field 6 at the Experiment Station, on a flat area of very sandy soil, confirm the earlier responses

recorded in the continued higher yields from treatments receiving cattle manure and artificial 'complete' fertilisers. Where phosphorus and nitrogen only have been supplied and potash has been omitted, yields are significantly below those of the unmanured trees. Yields and girths of the various fertiliser treatments are closely correlated.

III. Cultivation

COVER CROPS

Field tests on methods of controlling sheet lalang in open situations were made throughout the year at the Experiment Station. Comparisons of different strengths of sodium arsenite solution showed that under favourable conditions 1½ per cent. sodium arsenite was as effective as stronger solutions.

The efficiency of spraying liquids is generally increased by the inclusion of a small amount of wetting or spreading agent which, by the reduction of surface tension of the spraying liquid, induces a quicker, more extensive and more uniform distribution of the solution over the leaf surface. Several wetting agents became available locally and tests were made, in the laboratory and in the field, with small amounts of the wetting agents included in the arsenic spraying solutions. These tests indicated that a sodium arsenite solution of one per cent concentration in which the wetting agent is included was as effective as the stronger sprays which contained no wetting agent.

Other weed killers were also tested for controlling lalang, with the object of finding for sodium arsenite a substitute which would be as economical and effective without having the disadvantages of being a dangerous poison and unpleasant to handle. The chemicals tried included forms of 2, 4-dichlorophenoxyacetic acid, pentachlorophenol, and both ordinary 'diesel' and 'aromatic' oils, but none of the substances used fulfilled the above requirements.

Oils were very promising at the start, but although they have a quicker initial killing effect on blades of lalang, they were found to be no more effective over a period than sodium arsenite, and are considerably more expensive.

The spraying trials which were carried out confirmed earlier views that pre-treatment of lalang by slashing or chipping does not help its eradication but that the mat of dead lalang tops which accumulates after several rounds of

spraying plays an important part in controlling regeneration of the lalang by its smothering effect on young shoots as they appear.

Attempts were made to prepare oil/water emulsions, but they were not very successful, and the possibility of using emulsions, which will be cheaper than pure oil sprays, remains to be investigated.

Chemical analyses of lalang, before and after spraying, were made to ascertain to what extent arsenic is translocated into the root system. No consistent evidence could be obtained of any substantial movement of arsenic into the rhizomes.

Leaching tests were made in the laboratory, using sodium arsenite solutions on inland soil types. On average inland loams to clay loams, no arsenic was detected in the leachate, although traces were found in a leachate which passed through twenty inches of sandy soil after two applications of $2\frac{1}{2}$ per cent. sodium arsenite solution. The result supports the view that in catchment areas and in the vicinity of wells, etc., the danger of water pollution from sprayed arsenic solutions is more likely to arise from the movement of surface water than from drainage water through the soil.

HOLING

A comparison was made in a replanting on a sandy loam soil between different sizes of planting holes, and the heights of rubber seedlings measured at one year from planting indicated that elaborate holing preparations were unnecessary. Normal heights of seedlings were obtained using six-inch holes, *i.e.* the minimum movement of soil required for applying fertilisers.

IV. Mechanical Cultivation

Although one or two large groups of estates used machinery for clearing land for replanting and for eradicating lalang, little information became available on mechanical operations for the cultivation and growing of rubber trees. For small-scale replanting tree-poisoning has become the favoured method of killing and removing the old stand of trees.

Observations were made from time to time on an estate where a small type of rotary hoe was being used to eradicate lalang in a replanted area. Old rubber stumps, partially hidden in the lalang, were obstructions which had to be avoided

and their lateral roots caused frequent stoppages and breakdowns of the machine. In addition, the replanted seedling rubber stumps had to be avoided. Even after making allowance for the disadvantages caused by these interferences with the efficient working of the rotary hoe, the conclusion was drawn that although it could conveniently prepare nursery sites or similar small areas, it was not suitable for large-scale control of lalang.

V. Laboratory Investigations

With only one Senior Officer available for the first half of the year, and with supplies of chemicals and re-agents only slowly arriving, little progress was made with investigational work.

Attention was given to improving methods of analysis, particularly for the determination of arsenic in biological material, and a method was satisfactorily adapted for routine use.

Towards the end of the year work was started on critical examinations of methods of determining exchangeable potash in soils and also estimating "available" or readily soluble phosphate.

The possibility was examined of using a modification of Neubauer's technique for estimating available soil nutrients. A special strain of padi was used as the extracting plant, and representative soils were tested. The uptake of phosphate was in all instances low or very low and covered only a small range; for one or two soils a negative result was obtained (in comparison with values from sand controls). The indications were that nearly all local soils are deficient in available phosphate and no satisfactory differentiation between them can be made on this basis by the Neubauer method.

Better separation between soils was achieved on the basis of uptake of potash by the padi seedlings but further work is required on this point.

The Neubauer method does not seem suitable as a routine laboratory method, but may be of value in investigational work on soils for differentiating types.

Tests were made to obtain information, by using the modified Neubauer technique with padi, on the effects of additions to soil of nitrogen, phosphorus and potash nutrients, on the utilisation by plants of phosphorus and potash.

The following results were obtained:—

- (1) Uptake of phosphate by indicator plants for coastal alluvial soils, this was increased by the addition of the other nutrients;
for inland soils, the utilization of existing soil phosphate was not affected, but the uptake of added phosphate was reduced by the addition of nitrogen.
- (2) Uptake of potash by indicator plants .. for all soils, this was unaffected by the addition of nitrogen, where phosphate was added the uptake of added potash was increased, and of existing soil potash was usually increased.

Some time was devoted to a study of methods for estimating the arsenic content of latex in order to ascertain whether the use of arsenic sprays in areas of growing rubber was likely to cause an absorption of arsenic by the tree into its latex.

The laboratory analytical work carried out in 1948 may be summarised as follows (figures in brackets give numbers of determinations).

Soil samples, in connection with soil survey—	235 (4,036)
Samples of soils, fertilisers, etc. for advisory purposes	—378 (4,100)
Investigational analyses, on soils, plant materials, rubber wood, rubber leaves, pot cultures, Neubauer tests	— (2,262)

In order to improve the maintenance of and working conditions for the more delicate types of apparatus, tests were made with a "De-humidifier", which is a machine with a small capacity for condensing atmospheric moisture. It was installed in the balance room and maintained a relative humidity, during constant running, of 66 per cent. to 70 per cent. As a result of the tests it was decided to air-condition the balance room.

Plans were prepared for improving and extending the fume cupboard arrangements.

VI. Advisory Work

CORRESPONDENCE AND VISITS TO ESTATES

Advisory work was maintained throughout the year in spite of the emergency, although visits to estates were fewer because of the reduced Senior Staff.

The main subjects of enquiry were general manuring and replanting, and lalang eradication. Relatively little interest has been shown in mechanical cultivation. The possibilities of intercropping new or replanted stands of rubber with other economic crops are being examined by some groups of estates in Malaya.

Statistics relating to correspondence and visits are as follows:—

Visits to estates	— advisory	..	55
	— experimental	..	18
Visits to R.R.I. Experiment Station		..	37
Correspondence	— advisory	..	643
	— experimental	..	213
Interviews at the Institute		..	132

During his visit to the United Kingdom the Head of the Division attended as one of two delegates from Malaya, a conference on Tropical and Sub-tropical Soils, held at the Commonwealth Bureau of Soil Science, Harpenden, England, in June 1948. The Conference made general recommendations regarding the study of tropical soil problems, and specifically for future work on soil classification and soil fertility in tropical regions.

The Head of the Division was a member of an informal committee appointed by Government to consider the dangers arising from the use of sodium arsenite as a weed killer and to recommend any precautionary measures which should be taken. Subsequently, legislation based on the report of the committee was passed by the Federal Government.

Considerable time towards the end of the year was taken up by administrative matters concerning new salary scales for the Junior Staff, and in organising security measures at the Institute and for members of staff when travelling to estates. The latter measures included the conversion of a car into an armour-plated vehicle and the administration of the special constables who will act as escorts when visits are made to estates.

PUBLICATIONS

An advisory leaflet, S/AL.10(48) was issued in February, giving a schedule of fertiliser applications suitable for replanted rubber trees.

C. G. AKHURST

Head of Soils Division

KUALA LUMPUR

November 1949

REPORT FOR THE PERIOD SEPTEMBER 1945 TO DECEMBER 1948 BOTANICAL DIVISION

STAFF

Mr. C. E. T. Mann returned from recuperation leave after serving as a prisoner-of-war on 20th July 1946. He acted as Director of the Institute from 20th July to 20th August 1946 and was appointed Director from 1st December 1946.

Mr. C. C. T. Sharp returned from Ceylon on 27th November 1945 and acted as Director until 19th July 1946, and as Head of the Botanical Division from 27th November 1945 to 20th August 1946. He was appointed Head of the Division from 1st December 1946. He left Malaya on long leave on 8th September 1947 and return to duty on 24th March 1948. From 16th May to 25th September 1948 he acted for the Director during his absence in London.

Dr. E. D. C. Baptist returned from recuperation leave on 22nd June 1946 and acted as Head of the Division from 8th September 1947 until 23rd March 1948 and from 16th May to 25th September 1948.

Mr. N. Wright and Dr. R. Scott Russell did not return to Malaya on the completion of their recuperation leave.

Mr. E. G. B. Gooding was appointed Botanist on 8th February 1947. He acted as Smallholders' Advisory Officer from 6th July 1948 until the end of the year.

Mr. H. M. Burkill was appointed to the Division on 1st July 1948 and was fully engaged until the end of the year in the collection of clonal seed for supplying to smallholders.

Mr. K. N. Kaimal returned from leave in India and resumed duty on 8th July 1946. Mr. T. V. Vaidyanathan left on long leave on 21st August and returned on 9th December 1946.

Leave had become due to many members of the Junior Staff during the Japanese occupation, and this was taken whenever possible before the end of 1946.

It is with great regret that the death is recorded of Mr. E. E. Pyke as a prisoner-of-war in Siam. Mr. Pyke was seconded for two years by the British Rubber Producers' Research Association to the Institute for work on the physiology of latex production.

The deaths during the occupation of two members of the Junior Staff must also be recorded with regret:

K. M. Sithambaram appointed to the Institute in November 1926 after service with R.G.A. laboratories on Petaling Estate, and Wong Din appointed in February 1938 after serving as a skilled budgrafter from 1930.

After the reoccupation of Malaya in September 1945 inventories of chemicals and apparatus were made and indents to replace the missing articles were prepared and sent to London.

The losses of apparatus were not serious and the total indents were small considering that very few purchases had been made since 1939.

During the last few months of the Japanese occupation the Botanical laboratories were in the charge of a Major Adachi assisted by two "apprentices." It is said that it was during this period that the greater part of the Divisional files and records were stolen. The keys of the laboratories and the filing cabinets were at that time in the custody of Major Adachi and his apprentices. The contents of the files were removed and the file covers replaced in their cabinets. Waste paper at the time was fetching a very high price and was easily disposed of.

It is however gratifying to note that the greater part of the records of the plant-breeding work carried out in 1937-1941 has remained intact. These records were stored separately from the other Divisional records and were removed in 1943, partly by Mr. Vaidyanathan to the Experiment Station and partly by Mr. S. Karalasingam to his quarters in Brickfields Road. A great debt is owed to these two officers for their foresight and care for the interests of the Institute.

Much of the time of the Division was spent in restarting some of the field experiments on the Experiment Station, and bringing into tapping for the first time experiments which had been laid down before the war. In addition many field experiments set up on estates were brought into tapping and arrangements were made for recording the yields.

Details of the work done will be given in the appropriate sections below, and it will suffice to say here that the greatest difficulty encountered on the Experiment Station was the loss of a large part of the labour force and the poor quality of that which remained. To add to our difficulties the tapping and recording of those experiments which had been restarted was interrupted by a strike of the labourers lasting for a month in November and December 1946. By the end of 1947

the position had greatly improved and in 1948 was back to normal.

It was not until the second half of 1946 that there was a member of the Senior Staff employed solely in the Division and early progress was necessarily slow.

RESEARCH

SECTION I. BREEDING AND SELECTION

(1) Pollination

It was not practicable to undertake any hand-pollination in 1946 but a small programme was undertaken in 1947. None of the trained pollinators employed before the war was available and new boys had to be taught. In these circumstances it was thought better to concentrate on a few large families rather than to attempt a more ambitious scheme. Considering the lack of skill of the pollinators the results (Table I) were not unsatisfactory.

A total of 6,832 hand-pollinations were made during the main seeding season in 1948. Much rain fell during this period and the proportion of successes is consequently below the average. This was followed by very dry weather in the middle of the year which had a bad effect on the quality of the seed, much of it being light with poor germination. The details will be found in Table II.

Some promising but unproved clones now being tested on a small scale were used as parents for the first time. Where known the parents of the clones used for pollination are given in the Table.

(4) Selection of Clones and Seedlings in Laboratory and Field

(i) A number of seedlings were test-tapped on the ten-days system for the first time in January 1932 at the age of $3\frac{1}{4}$ years and thereafter at intervals of six months until they were $5\frac{3}{4}$ years old. The yields at test-tapping have been correlated with the yields on regular tapping S/2, d/2, 100% and the details are set out in Table III. The values of the correlations have fallen steadily during the fourteen years since tapping commenced, but they are still fully significant.

(ii) Clones R.R.I. 500-522 and B.84 in Field 30 were test-tapped on the ten-days system in 1941. This field was budded

TABLE I. Results of Hand-Pollination 1947

Family No.	Cross	No. of Pollinations	No. of Fruits harvested	Successes per cent.	No. of Seeds		Germination per cent
					Planted	Germinated	
1.	Tj. 1 x R.R.I. 501	2,360	74	3.1	223	126	56.5
2	Tj. 1 x R.R.I. 507	1,239	59	4.8	179	120	67.0
3	Tj. 1 x R.R.I. 500	1,529	25	1.6	78	60	77.0
4	R.R.I. 501 x B. 84	1,246	38	3.0	114	90	79.0
5	R.R.I. 501 x R.R.I. 507	1,438	32	2.2	96	72	75.0
	Total	7,812	228	2.9	690	468	67.8

	Cross	Parents		No. of Pollinations	No. of Fruits harvested	Successes per cent.	No. of Seeds	No. of Seeds germinated	per cent.
1	33/103 x Tj.1	P.B.49 x B.84	A.44 x L.N.	255	13	5.1	39	26	66.6
2	33/103 x R.R.I. 501	"	"	409	29	7.1	87	45	51.7
3	33/103 x L.N.	"	"	53	2	3.8	6	4	66.6
4	33/103 x B.R. 2	"	"	68	2	2.9	6	—	—
5	33/129 x Tj.1	"	"	507	9	1.8	27	6	22.2
6	33/129 x 501	"	"	510	24	4.7	72	57	77.6
7	33/129 x 32/599	"	Tj.1 x P.B.86	309	12	3.9	36	26	72.2
8	33/129 x L.N.	"	"	65	3	4.6	9	4	44.4
9	33/520 x R.R.I. 501	Tj.1 x P.B.24	A.44 x L.N.	223	15	6.7	45	30	66.6
10	33/520 x R.R.I. 500	"	A.44 x B.84	202	13	6.4	39	31	79.5
11	32/599 x Tj.1	Tj.1 x P.B.86	"	348	4	1.1	12	—	—
12	32/599 x B.84	"	"	395	21	5.3	64	46	73.0
13	32/599 x R.R.I. 501	"	A.44 x L.N.	161	—	—	—	—	—
14	32/599 x R.R.I. 500	"	A.44 x B.84	269	26	9.7	78	59	75.6
15	32/599 x L.N.	"	"	369	18	4.9	54	29	53.7
16	32/599 x B.R. 2	"	"	188	4	2.1	12	10	83.3
17	32/711 x R.R.I. 501	Tj.1 x P.B.49	A.44 x L.N.	266	15	5.6	45	38	84.4
18	32/711 x B.84	"	"	89	4	4.4	12	10	83.3
19	32/711 x R.R.I. 500	"	A.44 x B.84	263	15	5.7	45	36	80.0
20	44/550 x R.R.I. 501	Tj.1 x 507	A.44 x L.N.	370	12	3.2	36	28	77.7
21	44/550 x L.N.	"	"	235	4	1.7	12	10	83.3
22	44/553 x R.R.I. 501	Tj.1 x B.84	A.44 x L.N.	365	20	5.5	60	54	90.0
23	44/553 x L.N.	"	"	283	—	—	—	—	—
24	34/320 x R.R.I. 500	Tj.1 x R.R.I.509	A.44 x B.84	330	5	1.5	15	11	73.3
25	34/320 x B.84	"	"	70	9	12.8	27	20	74.0
26	34/373 x 500	R.R.I.504 x R.R.I.509	A.44 x B.84	230	10	4.3	30	22	73.3
Total				6,832	289	4.2	868	602	69.4

TABLE III. *Relationship between Yields at Test-tapping and Yields obtained in Continuous Tapping*

No. of Test-tapping	Age of Trees at Test-tapping Years	Correlation between Yield at Test-tapping and yields in Continuous tapping								
		6½-7½ Years	7½-8½ Years	8½-9½ Years	9½-10½ Years	10½-11½ Years	11½-12½ Years	17½-18½ Years	18½-19½ Years	19½-20½ Years
1	3½	+ 0.77	+ 0.68	+ 0.58	+ 0.46	+ 0.48	+ 0.40	+ 0.36	+ 0.35	+ 0.28
2	3½	+ 0.75	+ 0.76	+ 0.64	+ 0.53	+ 0.53	+ 0.47	+ 0.39	+ 0.37	+ 0.30
3	4½	+ 0.85	+ 0.77	+ 0.69	+ 0.69	+ 0.60	+ 0.49	+ 0.45	+ 0.43	+ 0.30
4	4½	+ 0.83	+ 0.86	+ 0.65	+ 0.54	+ 0.54	+ 0.47	+ 0.48	+ 0.42	+ 0.32
5	5½	+ 0.80	+ 0.80	+ 0.70	+ 0.59	+ 0.62	+ 0.61	+ 0.47	+ 0.40	+ 0.37
6	5½	+ 0.85	+ 0.83	+ 0.74	+ 0.64	+ 0.64	+ 0.59	+ 0.50	+ 0.44	+ 0.39

Level of significance for $P = .01$, $r = 0.26$.

Height of tapping in January 1948 = 12 inches.

in October 1937 and the trees were 3 years and 8 months old at the time of testing.

The yields from test-tapping can now be compared with the yields harvested during the first two years of regular tapping. The following correlations have been found:

- (a) Yield on test-tapping and yield in 1st year of regular tapping + .506.
- (b) Yield on test-tapping and yield in 2nd year of regular tapping + .478.

The correlations are surprisingly low and if this should be usual for budded trees the ten-days test would be insufficiently accurate for selecting clones at an early age.

(iii) The hand-pollinated seedlings made in 1937 were planted in the nursery and transplanted as stumps to Field 33B in 1939.

At the time of transplanting

- (a) the trees were pricked with a Cramer's knife and the length of flow of the latex was measured,
- (b) girth measurements were made,
- (c) bark samples of two large families of seedlings were taken and the diameter of the sieve-tubes was measured in the laboratory.

When the trees were cut back in the nursery for transplanting the tops were used as budwood and a clone of about seven trees was made from most of the seedlings. The mother-trees and the clones made from them were brought into tapping and the yields were recorded from 1946. The correlations between the various factors are set out in Table IV.

The length of flow of latex after pricking with Cramer's knife has proved quite valueless as a means of selection. This confirms previous experience with this tool.

Gunnery, (*J. Rubb. Res. Inst. Malaya* 6 1935) showed that all high-yielding trees have large diameter sieve-tubes and that trees with small diameter tubes invariably have low yields. In the two families studied, although the sieve-tubes varied in diameter, they were all in the large class and the differences of diameter within that class have had no effect on yield.

A satisfactory method of selecting high-yielding trees at an early age still remains to be discovered.

TABLE. IV. *The Relationship Between Yield and Other Characters in Budded and Seedling Trees*

Correlations		Family 15 Av.157 x P.B.49		Family 19 Tj.1 x P.B.86	
		No. of pairs	Correlation r.	No. of pairs	Correlation r.
1. Length of flow of latex of mother-tree on pricking	} Diameter of sieve-tubes of seed- ling mother-tree ..	45	- .1663	50	+ .2227
2. -do-	} Yield of seedling mother-tree ..	45	- .0758	39	+ .0669
3. -do-	} Yield of clone ..	45	- .1473	50	+ .3286
4. Diameter of sieve-tube of mother-tree	} Yield of mother-tree 1947 ..	45	- .0171	40	+ .2437
5. -do-	} Yield of clone 1947 ..	45	+ .0529	51	+ .1523
6. Girth of seedling mother- tree	} Yield of mother-tree ..	45	+ .1880	40	- .1939
7. -do-	} Yield of clone ..	45	+ .3270	51	+ .4339
8. Yield of mother-tree	} Yield of clone ..	45	+ .6667	40	+ .1004

(5) Testing of Seedling Families and Clones

(i) LEGITIMATE SEEDLING FAMILIES FROM 1937-1939 HAND-POLLINATIONS

(a) *The 1937 Crosses, R.R.I. Expt. Stn. Field 33B.* The hand-pollinated seedlings from the 1937 crosses were planted as stumps in October 1939 in Field 33B at the Experiment Station. Tapping S/2, d/2, 100% was started in April 1946 and the results are set out in Table V. For ease of comparison with later yields the yields for 1946 are calculated in lb. per tree per annum of 160 tappings.

The major part of the 1937 programme of crosses consisted of crossing three clones Tj.1, Av.157 and B.84 with each other and with P.B.24, 49, 86 and 186, G.1, B.D.5 and Av.33.

The three principal clones used, Tj.1, Av.157 and B.84 seem to be of about equal value as producers of high-yielding trees. Of the other clones P.B.49 is outstanding, the three families of P.B.49 being amongst the five highest yielders. Three other families with outstandingly good yields are B.84 x P.B. 24, Tj.1 x P.B. 24, and Tj.1 x Av.33.

The first tapping panel was tapped out and new panels were opened at 30 inches from the ground in January 1948. This has caused a general decline in yield of the seedling families in 1948 though not of the control trees on which tapping was continued on the original cuts.

In the third year of tapping the seedlings as a group yielded 25 per cent. more than the buddings of B.84 compared with 44 per cent. and 40 per cent. in the first two years of tapping.

The control clone B.84 is not one of the highest yielders of the proved clones in its first few years of tapping. It is, however, yielding at the rate of over 1,000 lb. per acre in the second and third years (there are 108 trees of this clone in tapping), and even when allowance is made for the advantage that the seedling trees have in the height of the tapping cuts, there can be no doubt that the best families are greatly superior to the control.

The incidence of Brown Bast (Table VI) has been rather heavy and altogether 18 per cent. of the seedling trees have been affected. Of the three major clones Avros 157 seems less likely to transmit a tendency to this disease than Tj.1 and B.84. Of the other clones used as parents P.B.24 and Avros 33 are more likely to transmit susceptibility to Brown

TABLE V. Yield of the 1937 Hand-Pollinated Seedlings for

Parents			Tjirandji 1						Avros				
			Trees tapped 1948	Yield lb. per Tree per annum and as percentage of Control						Trees tapped 1948	Yield lb. per T percent		
				1946		1947		1948			1946		lb.
lb.	per cent	lb.	per cent	lb.	per cent	lb.	per cent	lb.	per cent	lb.	per cent	lb.	
P.B. 86	..	54	8.0	129	11.3	112	9.5	96	51	7.8	126	1	
P.B. 24	..	23	11.6	187	18.0	178	18.1	183	17	6.7	108	1	
P.B. 49	..	42	15.4	248	22.1	219	19.2	194	46	11.8	190	5	
P.B. 186	..	27	8.0	129	14.4	143	11.9	120	—	—	—	—	
Av. 33	..	27	11.1	179	16.9	167	17.3	175	2	9.1	147	1	
Av. 157	..	14	6.6	106	16.3	161	13.9	140	—	—	—	—	
A. 44	..	—	—	—	—	—	—	—	8	7.4	119	1	
B. 84	..	2	6.7	108	11.5	114	10.3	104	17	9.9	160	1	
B. 58	..	52	9.0	145	13.0	129	11.5	116	—	—	—	—	
Tj. 1	..	—	—	—	—	—	—	—	14	6.6	106	1	
Gl. 1	..	22	7.3	118	10.9	108	10.5	106	14	6.3	102	1	
B.D. 5	..	4	5.8	94	11.0	109	9.0	91	22	7.2	116	1	
Mean	..		8.9		14.5		13.1			8.1		1	

Tapping System S/2, d/2, 100%.

Yield of Budded Control B.84	1946	1947	1948
	6.2 lb.	10.1 lb.	9.9 lb.

the years 1946-1948 R.R.I. Experiment Station Field 33 B

157				Pilmoor B. 84							Mean yield in lb. per tree		
Yield lb. per Tree per annum and as percentage of Control				Trees tapped 1948	Yield lb. per Tree per annum and as percentage of Control								
1947	1948				1946		1947		1948		1946	1947	1948
per cent	lb.	per cent			lb.	per cent	lb.	per cent	lb.	per cent			
10	129	10.8	109	27	9.0	145	12.4	123	9.4	95	8.3	12.2	9.9
7	155	13.6	137	18	12.9	208	17.9	177	13.9	140	10.4	17.2	15.2
6	184	16.4	166	36	12.9	208	14.7	146	11.9	120	13.4	18.5	15.8
—	—	—	—	7	8.1	131	12.4	123	12.1	122	8.0	13.4	12.0
7	106	7.8	79	5	10.9	176	13.7	136	15.5	157	10.4	13.8	13.5
—	—	—	—	17	9.9	160	17.9	177	15.8	160	8.3	17.1	14.9
9	108	9.3	94	—	—	—	—	—	—	—	7.4	10.9	9.3
9	177	15.8	160	—	—	—	—	—	—	—	8.3	14.7	13.1
—	—	—	—	—	—	—	—	—	—	—	9.0	13.0	11.5
3	161	13.9	140	2	6.7	103	11.5	114	10.3	104	6.7	13.9	12.1
3	112	9.8	99	5	7.6	123	11.9	118	8.3	86	7.1	11.4	9.6
3	142	10.9	110	25	9.3	150	12.7	126	11.6	117	7.4	12.7	10.5
3		12.0			9.7		13.9		12.1		8.9	14.1	12.3

The number of trees tapped is the number in tapping when the new panels were opened in January 1948

TABLE VI. Incidence of Brown Bast in 1937 Hand-Pollinated Seedlings in first three years of tapping

Parents	Tjirandji 1				Avros 157				Pilmoor B.84				Cases of Brown Bast		Total Trees	Total	per cent
	Total Trees tapped	Cases of Brown Bast			Total Trees tapped	Cases of Brown Bast			Total Trees tapped	Cases of Brown Bast			Total				
		1946	1947	1948		Total	1946	1947		1948	Total	1946		1947	1948	Total	
P.B. 86	64	7	2	9	54	—	4	3	7	29	—	6	1	7	147	23	16
P.B. 24	25	6	2	9	18	—	—	1	1	23	1	6	6	13	66	23	35
P.B. 49	44	1	3	4	46	—	1	1	2	33	—	3	1	4	123	10	8
P.B. 186	31	1	2	4	7	—	—	—	—	7	—	1	1	2	38	9	24
Av. 33	30	5	6	11	3	—	1	2	3	4	—	1	1	2	37	16	43
Av. 157	14	2	1	3	—	—	—	—	—	—	—	—	—	—	14	3	21
A. 44	—	—	—	—	9	—	1	1	2	—	—	—	—	—	9	2	22
B. 84	2	—	—	0	19	—	1	1	2	—	—	—	—	—	21	2	10
B. 58	52	5	1	6	—	—	—	—	—	—	—	—	—	—	52	6	12
Gl. 1	25	4	2	6	15	—	—	1	1	5	1	—	—	1	45	8	18
B.D. 5	4	—	2	2	23	—	1	3	4	28	—	—	2	2	55	8	15
Total	291			57	187				22	129				31	607	110	18
Per cent.				20	12									24			

Note: 1. Total trees tapped includes all trees that have been tapped at any time during the years 1946-1948 except those taken out of tapping on account of diseases other than Brown Bast.

2. Trees affected more than once with Brown Bast appear only once in this table.

Bast than the others, though the evidence from the smaller families of seedlings is not conclusive. Of the 108 budded trees of B.84, eleven contracted Brown Bast.

(b) *The 1938 Crosses, R.R.I. Experiment Station, Field 34 A.* The 1948 crosses were planted as stumps in October 1940. A selection of the 500-series of clones were crossed with each other and with Tj.1 and B.84. Tapping commenced in May 1946 but was stopped after six months by the tappers' strike. The yields are set out in Table VII.

It was intended to thin out the control buddings towards the end of 1941 before any of the effects of competition could be felt. Owing to the war this was not done until 1946. Their growth has consequently been suppressed and the yields are below normal.

The crosses of the 500-series with each other are of about the same average value as the 1937 crosses, but when crossed with Tj.1 and B.84 they give very much higher yields and are, on the whole, as good as or better than the best of the 1937 crosses.

The crosses between clones of the 500-series are usually rather lacking in vigour. Since all the 500-series clones used in these crosses have A.44 as one parent and since the self-pollinated trees of A.44 are known to be very weak growers, this lack of vigour is to be expected. The crosses of the 500-series with Tj.1 and B.84 are of average vigour and so also is the cross Tj.1 x Tj.16. The yields of the last family confirm the good results obtained at the Proefstation West-Java.

The incidence of Brown Bast has been much heavier than in the 1937 crosses, amounting to 33 per cent. of the total number of trees tapped. The incidence was particularly heavy in the third tapping year, when two-thirds of the cases occurred. A study of the records summarised in Table VIII, does not suggest that any one of the clones used is more likely to transmit a tendency to Brown Bast than the others.

Eight of the 109 budded trees of B.84 contracted Brown Bast over the same period.

(c) *The 1939 Crosses, R.R.I. Experiment Station, Field 38 A.* The 1939 crosses were planted as two-years-old stumps in October 1941. During the Japanese occupation the uncontrolled growth of the secondary jungle caused a severe check to the growth of the rubber trees which grew tall and spindly with thin bark. After slashing back the covers at the end of 1945 the growth improved rapidly and tapping commenced in June

TABLE VII. Yield of the 1938 Hand-Pollinated Seedlings for the years 1946-1948 in Pounds per tree per annum, and as a percentage of the Control.
R.R.I. Experiment Station Field 34 A.

Parents	No. of Trees tapped 1948	Yield lb. per Tree per annum and as percentage of Control				Parents	No. of Trees tapped 1948	Yield lb. per Tree per annum and as percentage of Control			
		1946		1947				1946		1947	
		lb.	per cent.	lb.	per cent.			lb.	per cent.	lb.	per cent.
R.R.I. 500 x R.R.I. 501	7	8.6	183	12.6	173	R.R.I. 504 x R.R.I. 509	36	9.7	206	13.4	184
" " 504	69	11.0	234	14.2	195	" " 511	55	8.7	185	12.4	170
" " 509	1	9.8	209	14.9	204	" " Tj.1	58	9.3	198	15.6	214
" " 511	8	10.0	213	13.5	185	" " B.84	24	8.4	179	11.2	153
" " Tj.1	8	13.8	294	19.2	263	R.R.I. 507 x Tj.1	14	13.9	296	18.7	256
" " B.84	1	4.3	91	3.2	44	" 509 x 511	6	10.1	215	11.7	160
R.R.I. 501 x R.R.I. 506	15	8.6	183	10.4	142	" 509 x Tj.1	4	14.1	300	21.9	300
" " 509	5	7.4	157	9.7	133	" 511 x Tj.1	11	7.3	155	12.0	164
" " 511	34	10.8	230	17.2	236	" 511 x B.84	6	9.9	211	14.7	201
" " Tj.1	23	11.0	234	19.5	267	Tj.1 x Tj.16	21	10.4	221	17.5	240
" " B.84	11	14.0	298	20.1	275	" x B.84	15	8.6	183	12.6	173
R.R.I. 504 x R.R.I. 506	15	9.2	196	11.6	159	B.84 Buddings	100	4.7	100	7.3	100
				11.5	151					7.6	100

Tapping System: S/2, d/2, 100%.

Planted October 1940.

Yields for 1946 estimated from actual yields harvested May-October.

The number of trees shown is the number tapped on the new panels opened in July 1948.

TABLE VIII. *Incidence of Brown Bast in 1938 Hand-Pollinated Seedlings in first three years of Tapping*

Parents	Total Trees tapped	Incidence of Brown Bast				per cent.
		1946	1947	1948	Total	
R.R.I. 500 x R.R.I. 501 ..	7	—	—	—	—	—
" x " 504 ..	72	2	6	18	26	36
" x " 509 ..	1	—	—	1	1	100
" x " 511 ..	8	3	—	2	5	62
" x Tj. 1 ..	8	1	—	5	6	75
" x B. 84 ..	1	—	—	—	—	—
R.R.I. 501 x R.R.I. 506 ..	16	2	2	5	9	56
" x " 509 ..	5	—	—	1	1	20
" x " 511 ..	35	—	4	7	11	31
" x Tj. 1 ..	23	—	2	6	8	35
" x B. 84 ..	10	—	1	3	4	40
R.R.I. 504 x R.R.I. 506 ..	15	—	—	2	2	13
" x " 509 ..	39	4	—	8	12	31
" x " 511 ..	56	1	1	9	11	20
" x Tj. 1 ..	60	5	—	10	15	25
" x B. 84 ..	24	—	1	3	4	17
R.R.I. 507 x Tj. 1 ..	15	2	—	9	11	73
R.R.I. 509 x R.R.I. 511 ..	6	1	—	2	3	50
" x Tj. 1 ..	4	—	—	—	—	—
R.R.I. 511 x Tj. 1 ..	11	1	—	2	3	27
" x B. 84 ..	6	—	1	1	2	33
Tj. 1 x Tj. 16 ..	22	1	2	5	8	36
" x B. 84 ..	16	—	2	4	6	37
Total ..	460	23	22	109	154	33

1947. The yield for the first year of tapping, June 1947 to May 1948, and a record of the incidence of Brown Bast are set out in Table IX. Considering the check to their development that the seedlings received in the early years the yields compare very favourably with those of the 1937 and 1938 crosses in the first year of tapping.

(ii) ILLEGITIMATE SEEDLINGS OF HIGH-YIELDING CLONES

(a) Twenty-six families of illegitimate seedlings of clones growing on the Experiment Station were planted as basket plants in Fields 15A and 23A in November 1936 in four replicated experiments. Surplus seedlings of these families were also planted, and budded in April 1938, with B.84 as a control.

TABLE IX *Yield of the 1939 Hand-Pollinated Seedlings in Pounds per Tree per annum for the first year of Tapping: June 1947-May 1948*

Parents	No. of Trees tapped	Yield in lb. per Tree	Cases of Brown Bast
Lun. N x B.84 ..	5	10.4	—
„ x Tj. 1 ..	4	11.5	1
B.R. 2 x R.R.I. 500	2	11.5	—
Lun. N x R.R.I. 501	16	9.3	1
Tj. 1 x B. 84 ..	102	9.1	14
Lun. N x R.R.I. 500	16	13.7	4
B. 84 Buddings ...	67	3.9	5

Tapping System: S/2, d/2, 100%.

At the same time, illegitimate seedlings from a duoclone planting of A.44 and B.84 on Pilmoor Estate were planted, with budded stumps of P.B.186 as a control.

Tapping and recording of the yields commenced in May 1946 and the yields will be found in Table X. The drop in yield of some of the families in 1947 must be attributed in part to the opening of new tapping panels at 30 inches from the ground in that year.

The best-yielding families are Tanjong Kemala (T.K.) 14, and Bogor Redgo 1 and 2. It is probable that many of the seeds of B.R.1 were obtained from crosses with B.R.2.

The incidence of Brown Bast varies greatly in the different families, seedlings of Av.52 and P.B.86 proving particularly susceptible in this experiment.

(b) The yields for the first year of tapping of various families of clonal seedlings from seven estate experiments are now available (Table XI). The control in every case consists of budded trees of B.84 and the yields of the families of seedlings are expressed as a percentage of the control, and, where known, also in pounds per acre per annum.

The following notes on the origin of some of the families may be of interest. Field 14A and B was planted with a mixture of clones made from crosses of the Pilmoor clones and

TABLE X *Yields of Illegitimate Seedlings for the years 1946-1948*
R.R.I. Experiment Station

Family	No. of trees tapped 1948	Yield lb. per tree per annum and as percentage of Control						Incidence of Brown Bast		
		1946		1947		1948		1946	1947	1948
		lb.	per cent.	lb.	per cent.	lb.	per cent.			
Pil. B. 16 ..	18	14.9	159	12.6	108	13.6	101	—	1	2
War. 1 ..	25	11.8	126	12.7	109	16.4	122	—	—	—
Lamp. 2 ..	20	14.1	150	13.9	119	17.4	130	—	—	—
T.K. 14 ..	20	22.6	240	20.1	172	24.0	179	1	—	—
R.A. 20 ..	29	15.6	166	13.4	115	14.4	107	—	—	2
B.R. 1 ..	31	17.2	183	18.9	162	20.2	151	—	—	1
T.K. 26 ..	16	11.9	127	11.3	97	13.7	102	—	—	1
B. 84 Buddings..	21	9.4	100	11.7	100	13.4	100	—	—	—
T.K. 12 ..	78	16.5	136	16.6	104	18.2	109	2	1	3
B.D. 7 ..	79	15.2	126	15.9	100	17.7	106	—	—	1
S.R. 1 ..	50	13.0	107	14.9	94	16.8	101	1	2	3
B.R. 2 ..	86	19.0	157	18.9	119	18.0	108	—	—	8
B. 84 Buddings..	94	12.1	100	15.9	100	16.7	100	—	—	1
Rub. 393 ..	55	14.6	113	18.2	105	19.1	114	—	3	1
Av. 183 ..	35	15.6	121	18.1	104	17.8	106	1	—	8
B. 84 ..	49	20.9	162	20.0	115	20.4	121	3	2	3
B. 84 Buddings..	44	12.9	100	17.4	100	16.8	100	—	1	—

Tapping System S/2, d/2, 100%.

Yield in 1946 estimated from seven months tapping, May-November

*in pounds per Tree per annum, and as a percentage of the Control
Fields 15 A and 23 A*

Family	No. of trees tapped 1948	Yield lb. per tree per annum and as percentage of Control						Incidence of Brown Bast		
		1946		1947		1948		1946	1947	1948
		lb.	per cent.	lb.	per cent.	lb.	per cent.			
P.B. 86 ..	59	14.6	100	15.0	133	15.6	147	—	9	7
Av. 185 ..	67	11.1	76	12.0	106	15.8	149	—	3	3
P.B. 49 ..	61	13.7	94	14.9	132	12.0	113	—	3	2
B.D. 5 ..	60	12.4	85	12.5	111	13.0	123	—	4	6
Tj. 16 ..	67	9.1	62	10.8	96	10.9	103	—	4	6
Gl. 1 ..	58	12.2	84	13.6	120	12.6	119	—	5	7
Av. 52 ..	54	16.1	110	15.6	138	13.2	124	5	5	8
B.D. 10 ..	74	11.5	79	13.0	115	12.5	118	2	1	1
Ct. 88 ..	70	10.8	74	11.4	101	12.1	114	2	—	2
B. 84 Buddings..	54	14.6	100	11.3	100	10.6	100	1	3	3
P.B. 186 ..	7	11.7	75	16.0	101	16.8	117	—	—	1
Av. 33 ..	4	16.2	103	19.3	122	11.1	78	—	—	1
P.B. 123 ..	16	17.5	111	18.8	119	18.4	129	—	3	—
B. 84 Buddings..	8	15.7	100	15.8	100	14.3	100	—	—	—
B. 84 x A. 44 ..	170	13.0	84	13.6	72	12.4	67	1	8	8
P.B.186 Buddings	32	15.4	100	18.8	100	18.4	100	—	2	1

Planted November 1936

TABLE XI *Yields of Clonal Seedlings in Estate Trials in lb. per acre per annum and as a percentage of the Control*

Estate	16		28		41		58		62		99		100/1	
	2.0		3.5		2.1		2.5		2.3		1.5		3.75	
Families	lb./ac.	per cent	lb./ac.	per cent	lb./ac.	per cent	lb./ac.	per cent	lb./ac.	per cent	lb./ac.	per cent	lb./ac.	per cent
B.84 buddings (control)														
Tj.1 Selfed		100	387	100	580	100	940	100	1,062	100		100	871	100
G.1 Selfed		126	598	155	842	145	990	105	1,181	111		97	1,528	175
Expt. Stn. F.14A. B.		104			614	106	954	100						
E.S.F.18 mixed		118	578	149	687	118	1,017	108		103		100	1,459	168
E.S.F.15N mixed		108	664	172	815	140	928	99	1,092			105	1,374	158
E.S.F.15N mixed		118					965	103				95		
P.B.I.S.G. C.D. & E.		119	731	189	755	130	1,019	108				105	1,771	203
E.S.F. 4A.		107	573	148	595	103	936	100					1,150	132
B.Kawan I.S.G.		103	708	183	752	130	938	99				112	1,314	151
B.84 x A.44		118	655	169			955	102	1,216	114		108	1,568	180
B.D.5 Selfed		112	490	127	784	135								
B. Rajah mixed		112	668	173	626	108			1,066	100		98	1,132	130
Gadek mixed		111			726	125								
Tj.16 Selfed		96			618	106								
Sab. 24 Selfed		112			633	109								
Rub. 393 Selfed		104			654	113								
Buloh Akar mixed		104			666	115								
E.S.F. 22 mixed		104			731	126								
S.R.9 ill		100			625	108			1,142	107				
R.R.1507 ill					786	136								
E.S.F.2		96			614	106						100	1,262	145
E.S.F. 16N					554	96								
P.B.25 Selfed		95							1,115	105				
Ct. 88 ill									1,153	109				
P.B.86 ill									1,261	119				
B.R.2 ill					656	113			1,190	112				

includes all but three of the clones of the 500-series. There are about 600 clones in this field altogether. Experiment Station Fields 4A and 16N contain hand-pollinated and illegitimate seedlings of the Pilmoor clones. The seeds from Field 2 were taken from a widely-spaced planting of Tjikadoe seedlings. The Field 2 seedlings in the estate experiments yielded about four pounds per tree per annum whereas the Tjikadoe seedlings themselves yielded about fifteen pounds per tree at the same age. The latter were grown under much more favourable conditions but it is unlikely that this could account for the whole of the difference in yield.

The order of merit in which the different families of seedlings occur varies greatly on the different estates.

(iii) SEEDLINGS FROM ISOLATED SEED GARDENS

(a) *Tjikadoe Seedlings.* The twenty-five families of seedlings from the Tjikadoe Seed Garden were tapped from January 1946 (except for three months from November 1946 to January 1947) and the yields will be found in Table XII. Family 17 has been consistently one of the highest yielders since tapping started in 1935 and in 1947 gave the exceptional average yield of 64 lb. dry rubber per tree per year which is more than three times that of the lowest-yielding family No. 11.

The stand per acre is low and half of the trees are late interplants which were budded when the original seedlings were already four years old. The initial planting distance of the Tjikadoe seedlings was 30 feet x 30 feet and they have had exceptionally good conditions for growth.

In December 1948 the tapping cuts were nearly at ground level.

(b) *Batu Kawan Estate I.S.G. Seedlings.* Tapping was restarted on the seven families of seedlings, identified by seed coat characters, from Batu Kawan Isolated Seed Garden and their yields will be found in Table XIII. The families now fall into two groups. The four families in the first group Av.49 and 157, P.B.23 and 25 all give very similar yields and on the average yield nearly 40 per cent. more than the other three families.

(iv) LARGE-SCALE CLONE TRIALS

(a) *Experiment Station Field 5.* Of the seven clone trials carried out in 1941 it has only been possible to restart the one in Field 5. From 1938 to 1945 the central trees of each plot were tapped on three different systems. Since 1946 they have been tapped uniformly S/2, d/2, 100%.

TABLE XII Yield of Seedlings from *Tijkadoe* Isolated Seed Garden Experiment Station Field 2.
Planted October 1928

Family	No. of Trees tapped 1948	Yield in pounds per tree per annum									
		1935	1936	1937	1938	1939	1940	1946	1947	1948	
1	7	6.6	10.5	12.2	13.6	20.2	23.9	30.2	38.2	27.9	
2	11	7.0	11.6	14.4	20.4	24.9	24.5	29.0	34.2	32.6	
3	9	4.0	7.2	8.5	13.0	15.9	17.4	15.2	20.0	18.6	
4	7	3.2	5.2	7.3	10.0	13.5	15.1	19.6	24.1	21.5	
5	11	2.9	5.1	4.6	6.7	9.4	11.3	14.9	24.5	21.5	
6	8	6.3	9.1	12.3	19.1	21.6	19.1	24.5	30.6	32.6	
7	11	6.5	12.2	14.4	20.2	24.6	29.5	22.0	31.4	34.9	
8	10	3.7	6.2	7.8	10.4	13.1	14.4	22.4	26.3	24.6	
9	3	5.4	9.6	14.1	20.8	27.8	28.4	25.6	47.7	38.6	
10	6	9.6	17.4	15.5	16.6	26.3	35.3	32.7	47.6	40.6	
11	7	3.4	6.6	6.5	4.5	12.0	16.8	11.0	17.2	16.4	
12	6	4.5	9.0	9.5	14.5	22.7	19.8	24.5	32.0	33.3	
13	5	5.5	5.8	6.7	11.0	14.5	14.5	15.9	19.9	21.3	
14	4	4.1	9.4	11.9	18.7	21.9	23.1	30.5	36.6	33.4	
15	11	7.0	11.1	14.3	20.4	28.6	25.9	24.7	42.2	40.6	
16	5	3.6	4.7	7.0	8.8	10.5	11.7	12.1	26.0	29.5	
17	7	8.4	12.2	21.7	26.4	29.4	33.4	31.1	64.3	53.1	
18	12	4.3	7.2	9.2	13.2	15.0	15.0	19.4	27.0	26.3	
19	10	4.6	7.1	8.6	11.8	17.8	17.8	17.8	26.3	25.8	
20	10	9.2	16.8	18.4	23.7	32.9	32.2	26.7	34.0	34.8	
21	6	11.3	9.6	12.0	15.8	23.2	23.7	32.6	45.8	38.9	
22	4	5.6	10.8	14.0	24.8	29.6	25.0	29.7	49.1	37.7	
23	7	5.2	7.7	9.4	14.0	16.2	21.0	23.0	36.3	30.6	
24	11	5.5	8.7	11.5	16.3	20.9	24.6	19.6	31.1	30.6	
25	8	3.1	3.7	5.2	10.0	15.1	16.2	18.8	30.0	29.7	
All families		5.5	9.0	11.1	15.4	20.3	21.6	22.9	33.7	31.0	

Tapping System S/2, d/2, 100%.

Age, January 1948, 19½ years.

Yields for the year 1946 estimated from ten months tapping, January-October.

TABLE XIII *Yield of Seedlings from Isolated Seed Gardens. Experiment Station F.20 A*

Family	Origin	No. of Trees tapped 1948	Yield lb. per tree per annum 160 tappings					Incidence of Brown Bast 1946-48
			1940	1941	1946	1947	1948	
Av. 157	Batu Kawan I.S.G.	39	6.8	9.3	21.1	20.1	18.4	4
P.B. 25	"	41	6.6	9.3	22.2	20.1	21.0	3
B.D. 5	"	41	6.4	8.3	16.1	14.3	13.4	5
P.B. 186	"	36	5.3	7.2	15.9	16.4	15.9	2
Av. 256	"	43	6.1	7.2	15.1	13.7	14.0	3
Av. 49	"	42	7.7	8.9	21.1	18.8	19.0	2
P.B. 23	"	29	8.7	10.4	21.2	19.3	20.0	2
Sab. 24	Changkat I.S.G.	41	6.0	7.2	13.1	12.6	12.8	2

Tapping System S/2, d/2, 100%. Planted November 1933.

Yield for year 1941 estimated from seven months tapping, January-July.

Yield for year 1946 estimated from six months tapping, June-November.

The highest yields (Table XIV) were obtained from Clones P.B.186, Tj.1, P.B.23 and Pilmoor B.84. Tj.1, the highest yielder for the period 1936 to 1941, has since the war been equaled by P.B.186 and B.84.

(b) *Clones R.R.I. 500-522. Experiment Station Fields 30 A and 30 B.* Early in 1937 thirteen of the clones being tested on a small scale in Fields 3 and 14 A and B were selected for testing on a large scale. These were budded in Field 30A in May, but since the rains stopped shortly after budding they were not cut back until October. Later in the year a further ten clones were selected and these were budded in Field 30B. In both fields B.84 was budded as a control. Four plots of a total area of 1.6 acres were allotted to each clone.

These fields were tapped for a short time during the Japanese occupation in 1945 but no yields were recorded. Regular tapping commenced in January 1946 and the yields in pounds per acre per annum and as a percentage of the control are given in Table XV.

There was a small drop in yield in 1948 of nearly all clones as the tapping cut approached the union of stock and scion. This is particularly noticeable in clone 512 though the early results from 1949 tapping indicates that the yield is recovering on the new tapping panels. Clones 501, 509, 511 and 513 are the best yielders.

Owing to the heavy incidence of Brown Bast in clones 500, 506, 516 and 519, it was decided to reduce the tapping intensity from May 1948 to 67 per cent. by shortening the tapping cuts to $\frac{1}{3}$ rd circumference which resulted in a considerable loss of crop. Full details of the incidence of Brown Bast are given in Table XVI.

(c) Clones of the 500-series were planted in a number of estate experiments before the war and many of these are now in tapping. The yields, as a percentage of the control clone B.84 and in pounds per acre per annum, where available, are summarised in Table XVII. The buddings are about two years younger than those in field 30 and the yields are generally lower, but the relative yields are on the average much the same as those found at the Experiment Station, except for clone 505 which does rather better on the estates and clones 511 and 513 which at first do not seem to do so well.

(d) *Clones R.R.I. 523-529. Table XVIII.* These seven clones are a later selection of the 500-series and are being tested on a large scale in Field 38B. The early growth was much retarded by competition with the uncontrolled belukar during

TABLE XIV *Yields of Budded Trees at the Experiment Station. Field 5.*

Clone	No. of tappable trees			Yield in lb. per tree per tapping (160 tappings)								Wind Damage				No. of trees out of tapping from Brown Bast		
	1946	1947	1948	1936	1937	1938	1939	1940	1946	1947	1948	up to end of 1940	1946	1947	1948	1946	1947	1948
Av. 49	290	285	285	4.6	6.5	8.9	9.8	10.4	13.1	15.3	15.6	—	—	—	—	4	2	4
Av. 50	280	277	273	4.5	7.0	8.8	10.4	9.9	10.6	14.4	15.1	—	—	—	—	2	2	1
Av. 152	295	293	284	3.7	4.8	5.9	6.5	7.5	10.2	13.4	13.6	4	—	1	—	2	2	6
B.D. 5	279	281	275	4.1	5.3	6.6	7.3	8.4	12.9	14.6	12.9	2	—	—	—	1	5	4
Pil. A. 44	248	247	246	8.1	9.0	9.5	9.8	10.4	14.3	16.9	16.4	27	—	—	1	2	3	6
Pil. B. 84	267	274	256	5.8	8.5	9.2	10.2	11.4	16.1	21.1	19.0	2	—	2	—	2	9	6
P.B. 23	248	251	247	4.9	7.7	8.8	10.1	11.1	13.7	17.9	20.7	—	—	—	—	—	3	5
P.B. 186	266	264	257	4.9	8.1	9.5	11.2	10.6	16.1	21.9	19.8	5	—	—	1	2	4	6
Tj. 1	267	267	258	7.4	10.2	12.2	13.9	14.0	13.9	21.2	20.4	7	1	—	—	2	7	9

Planted as budded stumps in November 1929. Tapped S/2, d/2, 100%.

The yields for 1946 have been estimated from the results of tapping from January-October and for 1947 from February-December.

TABLE XV *Trial of Clones R.R.I. 500-522. Yield in pounds per acre and as percentage of Control*
Field 30 A

Clone	1946		1947		1948		Clone	1946		1947		1948	
	lb./ac.	per cent.	lb./ac.	per cent.	lb./ac.	per cent.		lb./ac.	per cent.	lb./ac.	per cent.	lb./ac.	per cent.
500	1,269	142	1,769	145	1,207	94*	513	1,506	202	2,080	207	1,970	201
501	1,445	162	2,258	186	2,197	172	514	959	128	1,223	122	1,281	131
502	1,291	145	1,575	129	1,393	109	515	1,003	134	1,431	142	1,337	137
503	1,372	154	1,536	126	1,283	100	516	1,457	195	1,829	182	1,285	131*
504	1,504	169	1,901	156	1,751	137	517	847	113	961	96	967	99
505	792	89	1,000	82	1,009	79	518	744	100	1,028	102	1,168	119
506	1,280	144	1,606	132	870	68*	519	1,234	165	1,496	149	1,008	103*
507	1,199	134	1,267	104	1,407	110	520	1,171	157	1,508	150	1,367	140
508	1,159	130	1,779	146	1,792	140	521	1,258	169	1,572	157	1,371	140
509	1,644	184	2,060	169	1,923	150	522	1,235	165	1,328	132	1,103	113
510	1,350	151	1,531	126	1,358	106	B.84	747	100	1,004	100	978	100
511	1,693	190	2,079	171	1,923	151							
512	1,408	158	1,814	149	1,361	107							
B.84	892	100	1,217	100	1,278	100							

* Clones 500, 506, 516 and 519 were tapped S/3, d/2, 67% from May 1948 owing to the high incidence of Brown Bast.

Tapping System S/2, d/2, 100%.

Age. January 1946, eight years and three months from budding.

TABLE XVI Incidence of Brown Bast and Wind Damage in Clones R.R.I. 500-522. Experiment Station Fields 30 A and B

Field 30 A					Field 30 B							
Clones	Total Trees tapped	Cases of Brown Bast			Wind damage	Clones	Total Trees tapped	Cases of Brown Bast			Wind damage	
		1946	1947	1948				1946	1947	1948		Total
500	185	4	11	10	25	513	167	1	8	5	14	2
501	182	2	5	7	14	514	176	—	2	1	3	—
502	181	1	2	11	14	515	184	1	5	14	20	4
503	166	1	2	9	12	516	179	1	12	10	23	4
504	177	1	3	6	10	517	155	2	1	—	3	—
505	172	1	3	2	6	518	178	—	—	1	1	1
506	177	5	13	14	32	519	186	1	20	10	31	3
507	182	—	2	2	4	520	168	2	3	13	18	2
508	183	—	1	4	5	521	181	4	5	9	18	1
509	181	1	2	6	9	522	166	5	2	11	18	1
510	166	—	3	3	6	B.84	181	1	3	5	9	1
511	167	1	2	13	16							
512	166	4	5	10	19							
B.84	172	1	1	8	10							

TABLE XVII *Yields of R.R.I. 500-Series Clones in Estate Experiments*

Estate No.	20/a/4		20/a/2		14		16		28		41		39		44		175	
Clones	lb./ac.	% of Control	lb./ac.	% of Control	lb./ac.	% of Control	lb./ac.	% of Control	lb./ac.	% of Control	lb./ac.	% of Control	lb./ac.	% of Control	lb./ac.	% of Control	lb./ac.	% of Control
500	1,048	125	720	123				153	933	188	1,006	161				160	666	169
501	1,112	133	966	165				160	953	192	1,064	170				166	667	169
505	—	—	705	121	839	117		127	—	—	711	113				118	531	134
506	—	—	765	131	—	—		155	929	187	1,034	165				150	—	—
507	919	110	908	155				138	—	—	854	136				—	—	—
509	—	—	—	—	1,231	172		178	—	—	1,177	188				—	—	—
511	—	—	789	135	—	—		—	746	151	1,195	191				—	785	199
512	—	—	—	—	—	—		129	—	—	985	157				—	—	—
513	—	—	—	—	—	—		169	832	168	939	150				—	—	—
514	—	—	628	107	—	—		140	634	128	788	126				—	—	—
515	—	—	826	141	—	—		133	—	—	923	147				—	631	160
518	928	111	628	107	—	—		117	636	128	718	115				—	—	—
519	—	—	—	—	—	—		145	820	165	1,035	165				—	440	112
B.84	835	100	585	100	714	100		100	496	100	626	100				—	395	100

Tapping System S/2, d/2, 100%.

TABLE XVIII Trial of Clones R.R.I. 523-529. Experiment Station Field 38 B. First Year August 1947-July 1948

Clone	No. of Trees		Yield per acre		Yield per tree		No. of cases of Brown Bast	Wind damage no. of trees
	Total	Tapped	lb.	% of Control	lb.	% of Control		
523	277	178	573	129	6.4	164	3	6
524	286	197	562	126	5.7	146	1	2
525	279	166	601	135	7.2	185	5	1
526	278	254	773	174	6.1	156	1	2
527	297	221	774	174	7.0	180	2	1
528	278	261	247	55	1.9	49	2	3
529	287	186	612	137	6.6	169	3	2
B.84	279	229	445	100	3.9	100	—	1

Budded October 1941. Tapped System S/2, d/2, 100%.

the period 1942-1945 and the proportion of trees tappable is still low for the age of the trees. This has caused a low yield per acre, but the relative yields suggest that clones 523, 525, 526, 527 and 529 are comparable in yield with 501. The absence of clone A.44 from the parentage of clones 525 to 529 has greatly improved their vegetative characters.

(v) SMALL-SCALE CLONE TRIALS

(a) *New Clones from Estate Mother-trees* (Field 15 South R.R.I.E.S.). Each of the clones in this field is planted in a small plot with Av.50 as a control. The yields of the most promising of the new clones in this field were recorded from 1st January 1946 (Table XIX). The yield of R.R.I.107 after a poor start has increased steadily from the first year of tapping and amounted to 30 pounds per tree in 1946 and 26 pounds in 1947 and 1948. This clone has good secondary characters and might be tried on a small scale by estates. Another clone also giving excellent yields is R.R.I.142, a very vigorous grower with a large spreading crown and good secondary characters. There are other clones giving good yields, but their rate of progress has been very slow and a clone that does not yield well until the 15th year has little economic value.

(b) *Clone Collection* (Field 15 North, R.R.I.E.S.). This field was tapped from 1st January 1946 but at first no records were kept. Yields of four of the clones have been recorded since January 1948 (Table XIX).

(c) *New Clones from Legitimate Seedlings*. The yields in the small-scale trials of the original buddings of some of the R.R.I. 500-series of clones will be found in Table XX. During the occupation clones 500 and 502 were tapped for only a short time. The other clones were tapped continuously, though erratically, and towards the end at much below 100% intensity. The size of the flush crop resulting from the rest and low intensity of tapping was greater in 500 and 502 than in the other clones. But even after making allowance for the flush crops big increase in yield can be recorded notably in clones 512, 523, 524, 525, 527 and 529. Recording the yields of these clones ceased at the end of 1947.

(d) Seven hundred and seventy-eight new clones in Fields 32 and 33 made from the 1937 hand-pollinated seedlings were brought into tapping in July 1946, and 523 clones made from the 1938 crosses were tapped in fields 34 and 44 from May 1947. Several of these clones are showing good early yields and secondary characters.

Yield in lb. per tree per annum of 160 tapplings

Clone	1937		1938		1939		1940		1941		1946		1947		1948	
	Clone	Av.50	Clone	Av.50	Clone	Av.50	Clone	Av.50	Clone	Av.50	Clone	Av.50	Clone	Av.50	Clone	Av.50
R.R.I. 5*	3.5	4.4	6.7	5.0	10.8	5.6	13.5	5.8	14.6	6.1	24.0	12.9	23.0	13.0	18.6	5.2
27*	4.8	4.1	6.2	4.8	9.2	5.7	11.2	7.5	10.5	6.7	20.0	8.3	20.4	8.5	17.7	3.6
49*	5.4	4.0	7.1	5.4	9.8	5.2	11.6	6.4	11.7	7.5	20.2	13.3	22.3	14.6	17.2	6.4
71	5.9	6.0	5.3	3.6	8.8	5.2	15.0	6.2	19.5	6.8	38.9	16.3	32.1	13.0	36.4	6.0
88	4.8	3.7	6.8	3.9	8.6	5.6	11.6	6.6	—	—	—	—	25.0	12.7	19.2	8.0
99*	5.4	3.8	6.8	4.5	10.7	6.4	11.5	7.6	12.3	8.0	21.9	14.7	19.7	14.1	22.0	10.9
103	7.0	4.4	6.2	5.3	9.9	6.4	11.6	6.3	11.9	6.2	23.5	9.7	20.7	10.7	18.2	8.5
107*	5.4	3.8	7.8	4.4	11.5	4.4	16.3	5.0	18.4	6.1	30.4	11.3	26.5	10.2	26.6	4.0
121	4.3	3.9	5.0	4.3	7.6	6.9	8.7	8.0	—	—	—	—	21.5	10.1	20.3	7.7
138*	5.9	3.3	6.0	4.4	9.0	4.4	9.4	5.8	12.4	7.1	13.8	11.5	21.8	14.0	19.2	6.1
142*	6.8	3.5	7.5	4.4	11.5	5.3	13.2	8.0	13.5	8.8	24.6	13.0	30.9	15.2	33.1	5.9
178*	—	—	4.5	2.5	9.5	4.6	11.0	4.6	14.4	4.8	20.6	11.0	19.6	11.1	17.2	6.4
211	—	—	4.3	4.0	6.6	5.4	—	—	14.0	7.7	26.6	11.3	24.6	11.2	23.2	6.2
218*	—	—	3.0	3.1	6.3	2.6	—	—	9.5	4.6	24.6	13.7	25.7	12.8	21.2	6.5
221	—	—	3.0	3.2	5.4	4.4	6.9	5.1	10.6	4.5	28.5	14.9	25.9	13.9	17.3	10.4
229	—	—	3.6	4.2	6.4	4.8	—	—	11.5	5.2	25.7	11.9	25.8	10.4	27.0	5.9
Lun. N	7.4	3.9	9.0	3.9	10.5	6.0	11.9	7.5	15.3	8.2	—	—	—	—	19.2	7.3
P.B. 49	5.8	3.5	8.8	4.4	12.0	6.4	13.3	7.4	13.3	7.0	—	—	—	—	26.9	6.0
P.B. 123	9.1	3.1	9.6	5.4	12.0	5.0	12.7	7.7	17.2	9.0	—	—	—	—	26.3	10.4
P.B. 86	6.2	3.8	9.2	6.1	9.0	4.5	11.5	5.1	15.4	8.1	—	—	—	—	13.3	11.5

Tapped S/2, d/2, 100%.

Note 1. The yields are estimated for the whole year from seven months tapping January-July in 1941 and from ten months tapping, January-October, in 1946.

2. *These clones are being tested on a large scale in estate experiments.

3. From January 1948 all clones were tapped on new panels at 40 inches from the union.

4. The four clones from the clone collection were tapped throughout 1946-1947 but the yields were not recorded.

TABLE XX Yields of a Selection of Clones made from Legitimate Seedlings of the 1928-31 Series of Crosses

Clone No.	Origin of Mother-trees	Date budded	No. of Trees tapped	Yield in lb. per tree per annum								
				1936	1937	1938	1939	1940	1941	1946	1947	
R.R.I.												
500	B.84 x A.44	Nov. 1930	³ 3.3.4.4.4.4.4.3.	13.1 13.1	15.9 15.9	21.9 17.9	24.5 21.0	14.6 15.7	16.5 18.8	41.5 43.3	31.2 33.2	
501	A.44 x Lun. N	Oct. 1931	¹ 2.2.2.1.1.2.2.	8.9 9.3	18.2 18.2	25.3 26.3	26.0 25.0	35.0 35.0	24.3 28.6	36.2 22.7	— —	
502	B.16 x A.44	Nov. 1930	³ 3.4.4.4.5.5.4.3.	9.1 9.1	10.1 8.7	15.4 13.5	20.6 18.8	22.6 20.3	22.5 19.6	47.0 42.0	32.9 29.0	
505	A.44 x Lun. N	Oct. 1931	² 3.3.3.2.3.	8.9 7.1	11.6 10.4	14.8 13.6	15.3 16.4	23.0 24.1	— —	— —	— —	
506	B.84 x A.44	Nov. 1931	² 3.3.3.2.3.3.	6.5 7.6	11.8 13.8	15.5 16.1	22.5 22.5	14.1 16.2	27.9 29.2	— —	— —	
509	A.44 x Lun. N	Oct. 1931	² 3.5.5.5.5.5.5.6.	9.5 9.2	14.0 12.6	11.8 11.4	16.7 18.2	20.8 21.0	19.1 17.8	27.5 17.9	24.7 14.0	
511	A.44 x B.16	Nov. 1931	³ 3.4.5.4.4.5.5.5.	8.1 8.1	14.0 13.3	16.4 14.2	19.2 16.0	20.1 17.7	28.8 28.4	35.8 26.2	36.4 28.6	
512	B.84 x A.44	June 1932	² 2.3.3.3.3.2.3.2.	6.0 6.0	11.2 10.3	13.5 12.3	17.8 15.7	24.9 18.6	22.6 23.1	39.0 39.0	38.5 38.5	
514	A.44 x B.58	Oct. 1931	⁴ 4.5.5.5.5.5.	7.1 7.1	16.0 14.6	18.2 15.1	20.4 17.6	20.0 16.8	28.3 24.8	— —	— —	

515	A.44 x D.61	Oct. 1931	2 3.3.3.2.5.4.4.3.	1 6.5	14.2 13.9	17.2 17.0	19.9 19.9	21.2 21.2	31.4 31.4	42.1 25.8	35.9 16.4
523	A.44 x B.16	Oct. 1931	3 3.3.3.3.3.3.2.2.	5.2 5.2	11.4 11.4	14.2 14.2	18.2 18.2	19.3 19.3	21.4 21.4	31.3 31.3	45.3 45.3
524	A.44 x B.16	Oct. 1931	1 1.1.1.1.1.1.1.1.	4.4 4.4	11.4 11.4	19.0 19.0	24.6 24.6	19.6 19.6	17.9 17.9	39.0 39.0	34.0 34.0
525	B.84 x D.65	Apr. 1933	2 2.3.3.3.3.2.2.	— —	7.5 7.5	14.9 11.9	19.3 15.6	14.9 13.2	23.8 22.1	28.4 28.4	38.4 38.4
526	B.84 x D.65	Apr. 1933	3 3.3.3.3.3.3.4.	— —	4.1 4.1	11.6 11.6	18.7 18.7	23.0 23.0	24.3 24.3	30.2 32.1	31.8 28.8
527	B.50 x B.84	June 1932	3 3.5.6.6.6.6.5.	— —	8.2 8.6	14.5 11.5	24.5 18.7	26.5 19.7	20.6 17.3	22.7 21.4	29.6 20.4
528	B.84 x D.65	Apr. 1933	2 2.4.4.4.4.4.6.	— —	4.4 3.6	9.8 8.4	16.2 13.6	17.2 14.0	16.3 14.2	24.4 19.2	23.0 17.6
529	B.84 x D.65	Apr. 1933	2 2.2.2.3.4.4.	— —	— —	9.3 9.3	15.5 15.5	20.1 20.1	23.8 17.6	59.5 36.1	51.2 31.9

Yields estimated from seven months in 1941 and ten months in 1946. Two sets of figures are given for each clone. The upper figures are for the trees tapped continuously throughout the period 1936-1946 and the lower figures for the trees tapped in each year. Included in the latter are trees too small to tap in the first years and trees later taken out of tapping for Brown Bast or other reasons.

SECTION II. PROPAGATION AND PLANTING TECHNIQUE

(2) Stock-Scion Relationship

(i) EXPERIMENTS WITH TWINNED PLANTS

(b) Tapping and recording in the three experiments with twinned seedlings was resumed in 1947. A high correlation in yield per inch of tapping cut and girth is still shown between the pairs of twin seedlings (Table XXI).

(c) In Series I (Field 4C) illegitimate seedlings of A.44 and B.58 were twinned and, later, one member of each pair was budded with P.B.186, Tj.1, D.65 or B.D.5. In 1940 the budded trees were tapped on the stocks at the foot of the first panel. From 1941 until the end of the Japanese occupation in 1945 tapping was irregular and when recording was resumed in 1947 the tapping cuts were again on the stock at the base of the second panel. New cuts were opened in January 1948 on the first panel.

In 1940 the stocks budded with Tj.1, the most vigorous grower of the four clones, gave more than double the yield of their unbudded partners and 86 per cent. more in 1947. (Table XXII). On the other hand, the yields of the stocks budded with B.D.5, the weakest grower, were only half those of the unbudded trees in 1940 and 39 per cent. in 1947.

If the figures for 1947 are calculated as yield per inch of tapping cut the percentages would be 155 and 58 for Tj.1 and B.D.5 stocks respectively, suggesting that the differences in yield are not the results of differences in vigour alone.

The girth measurements taken in 1948, like those taken earlier (Annual Report 1939, p.90) confirm that the girths of the stocks are affected by the vigour of growth of the scions with which they are budded.

(d) In Series III (Experiment Station Field 22B) illegitimate clonal seeds of M.A.P. mixed, A.44, S.R.9, P.B.20 and P.B.24 were twinned and one member of each pair of twins budded with P.B.186, B.84 or Avros 50. The yields were recorded for 1940, 1947 and 1948 but so far the stocks do not appear to have influenced the yields of the scions in any way.

(3) Planting Density and Distribution

Density-of-Planting Experiment

Experiment Station Fields 14C and D. The yields and other data for the years 1932-1948 will be found in Table XXIII.

TABLE XXI *Girth and Yield of Unbudded Pairs of Twinned Seedlings, 1948*

Type of illegitimate clonal seedlings	No. of Pairs	Girth in inches at 50 inches from ground		Correlation Girth of (a) and (b) members	Yield in gms. dry rubber per tree per tapping		Correlation Yield per inch of tapping cut of (a) and (b) members
		(a) member	(b) member		(a) member	(b) member	
(i) Pilmoor A.44 and B.58	32	38.0	35.3	+ 0.7995	42.3	37.6	+ 0.8515
(ii) P.B.24	55	32.6	31.9	+ 0.7134	53.3	52.4	+ 0.8035
(iii) Mixed Clonal Seedlings	97	32.4	31.9	+ 0.687	51.8	45.8	+ 0.8480

Tapped: S/2, d/2, 100%.

TABLE XXIII *Density-of-Planting Experiment Field 14 C*
Planted December 1930 with 1

year of life					Percentage of Tappable Trees								Average number		
1941 11	1945 15	1946 16	1947 17	1948 18	1937	1938	1939	1940	1941	1946	1947	1948	1938	1939	1940
32.2	39.4	41.5	42.2	43.1	75	91	93	95	96	95	94	93	150	156	159
25.6	31.6	33.7	34.0	34.7	64	74	79	82	82	82	81	80	334	362	372
24.2	30.0	31.3	31.6	32.0	61	76	83	86	86	87	86	85	370	409	422
21.0	25.4	26.5	26.7	27.0	51	65	72	77	77	80	80	79	512	575	612
19.2	23.4	24.4	24.6	24.7	39	53	62	65	66	71	70	70	602	712	758
17.3	21.0	22.2	22.3	22.6	20	34	48	53	54	66	65	64	587	842	947

cluded from records.

results January-September.

„ January-October.

D—R.R.I. Experiment Station

and stumps of clone Avros. 50

trees in tapping			Yield in lb. per tree per annum								Yield in lb.			
1946	1947	1948	1937	1938	1939	1940	1941	1946	1947	1948	1937	1938	1939	1940
160	158	157	5.7	7.5	10.1	13.3	11.6	13.0	20.2	21.2	261	324	497	621
371	369	367	5.7	5.8	6.7	7.9	7.1	7.2	10.7	11.4	346	458	647	711
431	428	420	5.0	5.7	6.4	7.6	7.4	6.8	9.7	10.3	345	511	655	821
645	642	634	4.2	4.0	4.9	5.5	5.0	4.8	6.4	7.8	421	564	816	951
835	821	806	3.7	3.6	4.0	4.7	4.3	3.9	4.9	6.3	385	539	800	941
1,194	1,181	1,171	3.9	3.5	3.4	4.1	3.8	3.5	4.8	5.9	263	464	742	951

Yield lb. per acre per annum					Yield lb. per acre 1937-1941 and 1946-1948		Bark Thickness in mm. (taken on 29.1.48)		
1941	1941	1946	1947	1948	Total	Mean	Virgin Bark	Renewed Bark 7 years	Renewed Bark as % of Virgin Bark
32.2	546	608	936	970	4,762	595	12.4	9.9	80.8
25.6	645	648	956	1,006	5,422	678	10.2	8.3	81.4
24.2	803	748	1,060	1,112	6,058	757	9.9	8.0	81.0
21.0	875	874	1,156	1,398	7,062	883	8.2	6.6	81.6
19.2	864	849	1,051	1,325	6,756	845	7.9	6.4	81.0
17.3	923	1,016	1,367	1,666	7,393	924	7.5	5.9	78.8

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The effect of density on growth is very marked, the trees in the A plots having about double the girth of these of the E plots in 1948. The difference in girth is still on the increase and in the two years December 1946 to December 1948 the A plots increased in girth by 1.6 inches compared with only 0.4 inches in the E plots.

For the first time since the experiment started the C plots planted at 222 to the acre failed in 1941 to give the highest yields, which were obtained by the E plots. On the resumption of tapping in 1946 the difference between the yield of the E and C plots steadily increased to 268 lb. per acre in 1948. But since this increase was only obtained by tapping sixty per cent. more trees, 278 to the acre compared with 176, it would not be economic to retain so high a stand.

The yields of the D plots planted at 302 to the acre are still unaccountably low.

(6) Planting and Tree Poisoning

(i) REPLANTING EXPERIMENT

An experiment has been set up on 40 acres of 20-years-old seedling rubber on the Experiment Station to compare various methods of reducing the non-productive period of rubber land between clearing the old stand of rubber and bringing into tapping the new replanted trees.

The four treatments are:—

A. Felling, clearing and replanting for budding in the field. This is the standard pre-war method and will be used as a control.

B. Planting stumps between the existing rows and poisoning the old rubber after nine months during which time the field will be kept in tapping. Trenches to isolate the new plants from the roots of the surrounding old rubber will be dug.

C. The same as (B) but poisoning the old trees to be postponed until 13 months after planting.

D. Every third row of trees to be poisoned and replanted on the hedge system. The hedges will be 66 feet apart. Trees in the remaining rows will be tapped and not poisoned until the hedges have nearly reached tappable size.

A manuring experiment will be superimposed on the replanting experiment.

(ii) POISONING RUBBER TREES WITH SODIUM ARSENITE

The method of destroying old rubber trees before replanting by frill-girdling and poisoning with sodium arsenite is well known. Experiments have been set up to compare the effectiveness of frill-girdling and poisoning with ring-barking and poisoning with a paste made of sodium arsenite and tapioca flour.

Experiment 1. Fifteen seedling trees with an average girth of 30 inches were ring-barked and poisoned. The ring of bark removed was about one foot wide and altogether one-and-a-half pints were used of a thin paste made from ten pounds of sodium arsenite dissolved in one gallon of water. Except for one tree which took five months to shed its leaves, leaf fall was completed in two to three months from poisoning. In six to seven months from poisoning all trees showed signs of breaking up.

Experiment 2. Nine larger trees with an average girth of fifty inches were ring-barked and poisoned with a solution similar to that used in Experiment 1. With two exceptions leaf fall was completed during the third month from poisoning. Of the exceptions, one tree was bare of leaves after 48 days and the other still retained its leaves at the end of four months.

Experiment 3. A large-scale experiment to compare different strengths of sodium arsenite solution for use in frill-girdling and ring-barking has been set up on Fermanagh Estate. Observations will be taken on the time required for the trees to die and disintegrate and on the costs of the different treatments.

SECTION III. TAPPING

(1) Tapping Technique

Our assistance was sought in connection with a guard which had been invented to protect tapping cuts from rain. From an analysis of the results of tapping the commercially-tapped fields on the Experiment Station an estimate was made of the crop lost in a year from rain.

In the year November 1947-October 1948 there were thirteen holidays and therefore 353 days (366-13) on which tapping could have taken place. There were in fact only 298 days on which normal tapping took place and the full analysis is given in Table XXIV.

It was found from examination of the Experiment Station records that

- (a) on late tapping days 83 per cent. of the normal crop was harvested;
- (b) when rain interfered with tapping 76 per cent. of the normal crop was harvested.

It will be seen from the table that inability to tap on 25 days owing to rain accounted for nearly all the loss of crop.

TABLE XXIV *Analysis of Tapping*

Tapping	No. of days	Crop	Loss	Loss per cent
Early ..	298	29,800	—	—
None (rain) ..	25	0	2,500	7.1
Late (1) ..	17	1,411	289	0.8
Interfered with (2)	13	988	312	0.9
	353	32,209	3,091	8.8

(1) Estimated to be 83% of normal crop.

(2) " " 76% " "

It is unlikely that the whole of this loss of crop could be recovered even though the rain guards were perfectly efficient. The trees might be dry but it is believed that the tappers would not go out to tap if it were raining heavily. If it is assumed that they would tap on only half the wet days, the saving in crop under this heading would be 3.5 per cent. With a fully efficient rain guard there should be little loss from late tapping and very little from interference. It would therefore be theoretically possible to increase the crop by about $5\frac{1}{2}$ per cent. per annum with a rain guard. Even this is probably an exaggeration for it is unlikely that an increase in the number of tapping days could be made without a decrease in the average yield per tapping.

(2) **Economic Tapping Systems on Seedlings and Budded Trees**

(i) TAPPING EXPERIMENT No. 47. R.R.I. EXPERIMENT STATION FIELD 6, TABLE XXV

This experiment was started in August 1935 and is the oldest of our experiments with full-spiral tapping.

The trees were rested from May 1945 to April 1946. Tapping was restarted in May 1946 on the tapping cuts which had been reopened on renewed bark in August 1943.

Bark Consumption. In the first six years of the experiment bark consumption was at the rate of 9.1 inches per annum on the alternate-daily systems and equivalent to 10.3 inches on the fourth-daily systems. After resuming tapping in 1946 bark consumption increased to over one inch per month.

TABLE XXV *Tapping Experiment No. 47—R.R.I.E.S. Field 6.*
Relative yields of the four tapping systems.

Tapping System	Mean No. of Trees	Relative Yields			
		August 1935 to December, 1940	May to October, 1946	April to December, 1947	January to December, 1948
(1) Control Alternate-daily (S/2, d/2, 100%)	90	100	100	100	100 (2)
(2) Double-Cut Alternate-daily A.B. (2S/2, d/2, 3m/6, 100%)	180	104	91	87	110 (4)
(3) Double-Cut Fourth-daily (2S/2, d/4, 100%)	90	117	118	112	135 (1)
(4) Full-Spiral Fourth-Daily (S/1, d/4, 100%)	90	140	117	113	130 (2)

Note: Figures in brackets are new cases of Brown Bast developed during 1948.

The heights of the cuts in December 1947 were:—

System 1. Alternate-daily on a half-circumference

S/2, d/2, 100%	..	..	2 & 17½ inches.
2. Double-two A.B. 2S/2, d/2, 6m/12, 100%	..	..	10 & 28 "
3. Double-four 2S/2, d/4, 100%	..	..	9 & 27½ "
4. Full-spiral fourth-daily S/1, d/4, 100%	..	..	17½ "

The apparent drop in yield of system 2 (Table XXV) is to be expected. In this system periods of rest follow equal periods of tapping at 200 per cent. intensity. In 1946 tapping was resumed after a year's rest had been given to all systems and a similar involuntary rest from November 1946 to March 1947 has placed system 2 at a disadvantage with the other systems. It still remained the least satisfactory of the full-circumference systems in 1948. The full-spiral fourth-daily system has fallen in yield since the war and now shows no advantage over the double-four.

New tapping cuts were opened on half the control trees in January 1948 at 40 inches from the ground with the result that the yield fell from 12.2 pounds per tree in 1947 to 9.5 pounds in 1948. This has made the other treatments appear

to have increased considerably in yield in comparison with the control.

(ii) TAPPING EXPERIMENT No. 48. EXPERIMENT STATION
FIELD 5. TABLE XXVI

The comparison of the double-four system with tapping alternate-daily on a half-circumference cut on nine clones has been continued. Compared with the control the yields of the trees on the double-four system have declined steadily since 1937 when the system was first adopted until 1947. In 1948 there has been a small recovery but the yields still remain well below those of the control.

The average girth of the trees in November 1946 was 30 inches, but the trees in the double-four plots had an average girth of two inches less than the control trees tapped S/2, d/2, 100%. Very high yields were obtained at first from

TABLE XXVI *Tapping Experiment No. 48. R.R.I. Experiment Station Field 5*

Clones	Yield of Double-Cut trees as percentage of Control							
	From 1935-1937: periodic 2S/2, d/2, 3m/6, 100%		1937 to 1948 Continuous 2S/2, d/4, 100%					
	May 1935 to April 1936	May 1936 to April 1937	July to December 1937	January to December 1938	January to December 1939	May to October 1946	May to December 1947	January to December 1948
Avros 49 ..	99	79	127	93	87	58	56	57
„ 50 ..	97	82	128	115	98	91	90	97
„ 152 ..	103	107	166	116	117	87	73	83
B.D. 5 ..	77	83	122	109	99	72	62	77
Pil. A.44 ..	81	88	115	83	80	73	58	58
„ B.84 ..	91	95	127	115	99	73	67	77
P.B. 23 ..	86	80	132	118	86	81	79	81
„ 186 ..	82	84	124	83	75	74	67	78
Tjirandji 1 ..	90	77	103	96	72	63	57	74
Mean of all Clones ..	90	84	127	103	90	75	68	76

the double-four system and it is probable that this checked not only the growth of the trees but that of the renewing bark also which could account for the poor yields harvested now. The trees were five years and three months old from planting as budded stumps when first tapped and were brought into tapping when they had a girth of 18 inches.

Considerable differences in the response by different clones to double-four tapping can be observed. Hardly any decline in yield has occurred in Avros 50 whereas the yield of Pilmoor A.44 on the double-four system is only a little more than half the yield of the control.

(iii) TAPPING EXPERIMENT No. 100. R.R.I.E.S. FIELD 18

This experiment is a simple comparison of S/1, d/4, 100% tapping with S/2, d/2, 100% in a field budded with a mixture of sixteen clones. The results of the first year of tapping are set out in Table XXVII.

The response to full-spiral tapping in this field of seventeen-years-old buddings is far poorer than that found before the war when the buddings were six to eight years of age.

The cost of tapping per pound is 25 per cent. less on the full-circumference than on the half-circumference system but this saving is off-set by the increased proportion of low-grade rubber from full-circumference tapping. It is estimated that in the first year of tapping in this experiment with No. 1 rubber at cents 35½ a pound, scrap and lump at cents 14 a pound and tapper's wages at \$1.45 per diem there would have been a loss of about \$33/- per acre per annum as a result of adopting full-spiral tapping.

(iv) TAPPING EXPERIMENT 101. FIELD 21

An experiment has been set up to compare the following systems on seven clones:

S/1, d/4, 100%

S/1, d/4, 8m/12.67%

S/1, d/4, 12m/16.75%

S/1, d/4, 12m/18.67%

S/1, d/4, 18m/24.75%

TABLE XXVII Tapping Experiment No. 100. Yields for January-December 1948

Tapping Systems	No. of Trees tapped	Yield in lb.			Scrap and Cup lump as %age of total	Mean yield per tree per annum (lb.)			Mean D.R.C. of latex
		No. 1	Scrap and Cup Lump	Total		No. 1	Scrap and Cup Lump	Total	
S/2, d/2, 100%	1,380	27,086	2,218	29,304	7.6	19.6	1.6	21.2	39.2
S/1, d/4, 100%	1,865	32,797	5,386	38,183	16.4	17.6	2.9	20.5	39.0

(v) TAPPING EXPERIMENT No. 102. FIELD 21

A small-scale experiment on seven clones to investigate the effects of extending the interval between tappings from four to five and six days was set up. The tapping systems to be compared are

S/1, d/4, 100%

S/1, d/5, 80%

S/1, d/6, 67%

(vi) TAPPING EXPERIMENT No. 103. ULU KLANG

SMALLHOLDINGS—TABLE XXVIII

In this experiment approximately 200 trees of clones Tj.1 and B.84 are tapped on S/2, d/2, 100% and 200 trees on S/3, d/1, 20-25 days per month—the latter being a system commonly used by smallholders.

During the year the S/2, d/2, trees were tapped 166 times and the S/3 trees 291 times. The relative tapping intensities were, therefore, 100 per cent. and 117 per cent. respectively.

Although the tapping intensity of the S/3 trees was increased by only 17 per cent. the yield per tree increased by 33 per cent.

(vii) ESTATE EXPERIMENTS

The results of the first year of tapping of three experiments set up before the war on estates are now available (Table XXIX). The experiments are carried out as nearly as possible under normal commercial conditions.

Estate 28 is on peat clay soil in the Klang district.

Estate 16 is on undulating inland soil in West Pahang.

Estate 41 is on heavy clay soil in the Dindings.

On Estate 28 small increases in yield have been obtained on the full-spiral system for all clones except Glen. 1 and B.D.5.

Very different results are recorded from Estate 16 where a considerable drop in yield has taken place with every clone on the full-spiral system. This estate is in a disturbed part of the country and was tapped by Chinese tappers. The latter were later replaced by Tamils and an immediate increase in the yield of the full-spiral tasks compared with the half-spiral was recorded. A prolonged period of flow is normally found with full-spiral tapping and the improvement must be attributed to later collection of the latex by the Tamil tappers.

TABLE XXVIII Tapping Experiment No. 103. Ulu Klang Smallholding

Tapping System:		S/2, d/2, 100%				Tapping System:				S/3, d/1, 24d/30, 117%				
No. of Trees	Yield in lb.				No. of Trees	Yield in lb.				No. of Trees	Yield in lb.			Mean D.R.C.
	No. 1	Scrap	Total	Mean D.R.C.		No. 1	Scrap	Total	Mean D.R.C.					
194	1,100.9	50.2	1,151.1	31.4	197	1,506.8	49.1	1,555.6	31.0					

Yield per tree per annum No. 1 rubber only on S/3, d/1, 24d/30, 117% : 7.6 lb.

" " " " " S/2, d/2, 100% : 5.7 "

TABLE XXIX Results of first year of Tapping of three Tapping Experiments on Estates

Yield in lb. per acre per annum												
Tapping System:— Estate:—	S/2, d/2, 100%			S/1, d/4, 100%								2S/2, d/4, 100%
	28 Yield	16 Yield	41 Yield	28		16		41		41	Yield	% of S/2, d/2
				Yield	% of S/2, d/2	Yield	% of S/2, d/2	Yield	% of S/2, d/2			
Clones												
P.B. 86	..	714	848	1,216	757	106	665	78	1,024	84	1,162	96
P.B. 186	..	378	—	971	402	106	—	—	770	79	875	90
Glen. 1	..	873	—	1,863	798	91	—	—	963	52	1,233	66
D. 65	..	476	597	917	515	108	537	90	802	87	842	91
B.D. 5	..	286	—	693	285	100	—	—	603	87	591	85
Tj. 1	..	—	832	—	—	—	682	82	—	—	—	—
Tj. 16	..	—	851	—	—	—	605	71	—	—	—	—
B. 84	..	442	612	871	516	117	517	84	690	79	794	91

On Estate 41 the general yield level is very much higher and the relative yields of the full-circumference system lower than on the other two estates. The yields from the double-four system are rather better than from the full-circumference system.

The response of the clones to full-circumference tapping shows well-marked differences. G.1 has proved particularly ill-suited to this system and to a lesser extent B.D.5. On the other hand D.65 seems better suited to full-circumference tapping than the other clones under test.

Owing to the large amount of pilfering that takes place, it has not been found possible to keep reliable records of the amount of scrap and cup lump in any of the experiments. The total weight of rubber harvested if it were known would probably show the full-circumference systems in a better light.

SECTION IV. PHYSIOLOGY

(1) Nutrition

INJECTION EXPERIMENTS, CLONE B.D.5

Clone B.D.5 has been planted on many estates throughout Malaya and normally produces a poor head of foliage and at most times of the year appears to be partially wintering. In none of the manuring experiments carried out on this clone has any improvement been seen after applying one or more of the major elements Nitrogen, Phosphorous and Potash. An experiment was therefore set up on the Experiment Station to see whether the poor foliage could be attributed to a deficiency of any of the trace elements.

The trace elements were administered by an injection technique, similar to that employed by Roach at East Malling: ("Plant Injection as a Physiological Method"; *Annals of Botany* N.S. III, No. 9, January 1939).

Previous experiments had indicated that the best time for injecting the solutions into the trees was when the new leaves had become fully grown after wintering. Accordingly, the experiments described here were carried out in May and June 1947 in Field 19 at the Experiment Station.

The trace elements used were:

Zinc	..	0.05%	Zinc sulphate plus 0.05% (by vol.) Sulphuric acid.
Nickel	..	0.05%	Nickel " " " "
Copper	..	0.05%	Copper " " " "
Manganese	..	0.05%	Manganese " " " "
Iron	..	0.05%	Ferrous " " " "
Cobalt	..	0.05%	Cobalt " " " "
Molybdenum	..	0.05%	Sodium molybdate " " "
Boron	..	0.1%	Boric acid

In addition the major element magnesium was injected as 0.5% Magnesium sulphate.

Tap water was used as control solution.

Layout of Experiment

Each plot consisted of four trees planted in a square. Immediately after the injections a photograph of the crowns was taken from the centre of each plot. The camera was pointed vertically upwards so that the crowns of the four trees were silhouetted against the sky. At three-monthly intervals a fresh set of photographs was taken and a quantitative estimate was made of the density of the canopies in the manner described by Haines (*Expt. Journ. Emp. Agr.* Vol. X, April 1942).

Up to the end of 1948 no differences in the foliage of the treatments could be observed and the experiment was abandoned.

(2) Physiology of latex flow in response to tapping

(i) It is known that when latex flows from the tapping cut dilution with water from the bark tissues takes place and the latex from the cut is not therefore representative of the latex as it existed *in situ* in the vessels. Ferrand has described a technique by which the dry matter content of the latex as it exists in the latex vessels can be determined. This technique has been examined and is to be applied to a study of the effects of tapping on latex concentration and to a study of the relationship, if any, between Brown Bast and the extent of dilution of the latex on tapping.

The method, briefly, is as follows. The bark of the tree is pierced as far as the cambium with a sharp scalpel. The first drop or two of latex which exude are squeezed out of the vessels by the pressure of the surrounding cells and are considered to escape before dilution starts and to be representative of the latex *in situ*. These are collected and dried and

the dry matter content of the latex calculated. With care an accuracy of $\pm 1\frac{1}{2}$ per cent. appears to be obtainable. A study of the extent of the dilution of both the tapped and untapped bark has been made.

(ii) Ferrand drew attention to the high incidence of Brown Bast in clone Tjirandji 1 and the high dilution of its latex on tapping in contrast to the low incidence of Brown Bast and small dilution in clone Av.49 and suggested that the high dilution might be a cause of Brown Bast. The experiments described below were carried out to test this possibility.

A common method of checking the incidence of Brown Bast is to reduce the tapping intensity from one hundred per cent. to sixty-seven per cent. or even less. It follows that if, on comparable trees, the extent of dilution is less on a low than on a high tapping intensity there would be grounds for considering there was a relationship between high dilution and Brown Bast, but if there was no apparent difference in dilution it would be evidence that high dilution was not a cause of Brown Bast.

Four trees of clone Pilmoor B.84 and four of clone R.R.I. 501 were selected after they had been tapped S/2, d/2, 100% for about a year. The following were recorded:—

- (a) Percentage total solids (T.S.) of latex *in situ* taken from a point one foot below the centre of the tapping cut (A). This was considered to be representative of the latex drawn upon when the cut was opened at each tapping.
- (b) Percentage total solids of the tapped latex (B).
- (c) Volume of the tapped latex.
- (d) Ratio of B/A as a percentage. This gives a measure of the extent of dilution taking place on tapping, a high figure showing a small dilution and *vice versa*.

For the first eight tapping days of the experiment all the trees were tapped S/2, d/2, 100%. They were then divided into two groups, each containing two trees of B.84 and two of R.R.I. 501, in such a way that the mean dilutions expressed by the ratio B/A, (and as far as possible other characters) in the two groups were as alike as possible. Group I was then tapped S/3, d/2, 67%, while Group II continued on the S/2, d/2, 100% system. Twenty-six sets of observations were made during the next four months (Table XXX).

TABLE XXX *The Dilution of Latex as a result of Tapping*

	27.2.48-16.3.48 (Means of 8 sets of observations)				20.3.48-22.7.48 (Means of 26 sets of observations)			
	(a) % T.S. of latex in situ	(b) % T.S. of tapped latex	b/a	Volume of tapped latex (mls.)	(a) % T.S. of latex in situ	(b) % T.S. of tapped latex	b/a	Volume of tapped latex (mls.)
GROUP I. On S/2, d/2, 100% from 27.2.48-16.3.48 subsequently on S/3, d/2, 67% ..	45.4	34.1	75.2	135	47.4	39.0	82.5	62.7
GROUP II. On S/2, d/2, 100% through-out ..	44.3	34.0	76.8	116	44.7	37.2	83.9	82.3
Difference ..	1.1 ± 1.323	0.1 ± .492	— 1.6 ± 2.432	— —	2.7 ± .375	1.8 ± .682	— 1.4 ± 1.43	—
Significant Differences (P = .05)	—	—	—	—	1.04	1.8	2.86	—

Compared with Group II the trees of Group I after the change in tapping system showed:

- (a) a higher percentage total solids in the '*in situ*' latex;
- (b) a higher percentage total solids in the tapped latex;
- (c) no significant difference in the extent of dilution (B/A);
- (d) a lower yield of latex.

This experiment suggests that the higher dry rubber content (assuming that total solids and dry rubber content are in similar ratio in the two tapping systems) brought about by reducing the tapping intensity to 67 per cent. has been caused, not by a reduction in the amount of dilution that has taken place, but by a general increase in the concentration of the latex in the latex vessels.

These results seem inconsistent with the suggestion that a high dilution of the latex on tapping is a cause of Brown Bast.

(3) Rubber Seed for British Rubber Producers' Research Association

Three hundred freshly-picked rubber seeds were forwarded by air to Cambridge University for plant physiological research by the British Rubber Producers' Research Association.

SECTION V. ECOLOGY

(1) Association of *Hevea* and indigenous flora

(i) Regular observations of the changes in the flora in Field 27 at the Experiment Station have been continued and the results are being prepared for issue as a separate publication. The differences in yield per acre of rubber for the various treatments are very small.

(ii) A similar set of observations has been taken in a 150-acres experiment on Kirby Estate with five replications of six methods of cultivation.

The main cultivation treatments are (1) plots in which the jungle was felled but not burnt before planting with rubber and in which indigenous covers were allowed to develop, and (2) plots in which the jungle was felled and burnt before planting. Indigenous covers were allowed to develop in the burnt plots and in addition leguminous creeper and bush covers were planted.

The rubber was planted between August and December 1936 and botanical surveys were carried out in August 1938, in December 1939 and in November 1948.

When the rubber trees were five years old and their branches had nearly closed in to form a continuous leaf canopy the Japanese invasion took place and weeding and slashing were discontinued for about five years. During this period the surviving natural covers developed over the entire area into a dense undergrowth which was heavily slashed in 1947. The rubber trees then appeared to be fairly well grown and not to have suffered seriously from five years of neglect.

Differences in the composition of the flora and in the density of the ground cover remain well marked. In the unburnt area, at the time of the third survey, there was a fairly dense cover consisting of more than 89 species of which most individuals belonged to 36 species of non-erect plants. Erect forms of plants which grew intermingled with these formed only a small proportion of the total cover, for though they numbered 53 species their populations were small. Self-sown rubber seedlings were frequent among the latter. Below, on the soil surface, there was a thick mulch of decaying plant debris. The physical condition of the soil was good and there were no signs of soil wash.

In the burnt area the cover was thin and sparse with stretches of bare ground. It was composed mostly of erect plants of 67 species with rubber seedlings predominating over the entire area. Creepers and climbers of the types occurring in the unburnt plots were few and the creeping and bush legumes planted after the burn had completely disappeared except for a few Lamtoro bushes which appeared to be dying.

Growth measurements were taken at the time of the three botanical surveys. The results which are given in Table XXXI show only negligible differences in growth between the six treatments.

A full description of this survey will be published together with that of the main experiment in field 27 at the Experiment Station.

TABLE XXXI *Experimental area on Kirby Estate. Summary of girth measurements*

Original Cultivation and Cover Treatments	Girth in inches at 50 inches			Mean Annual Increments in inches over 5 years
	May 1940	January 1941	April 1946	
(1) No Burn: Minimum Control of Natural Covers (Subsequently slashed as in 3) ..	7.6	10.2	25.5	3.1
(2) No Burn: Natural Covers as in 1. Jungle stumps examined for root disease	7.5	10.1	25.3	3.0
(3) No Burn: As 2 but Covers slashed at intervals of 6 months at a height of 3 to 4 feet above ground ..	7.3	9.9	24.7	3.0
(4) Burn: Planted with Creeping Legume (Pueraria) ..	7.0	9.6	25.3	3.1
(5) Burn: Natural Covers slashed as 3 * plus Centrosema ..	8.3	11.1	25.5	2.9
(6) Burn: Natural Covers as 5 plus Leguminous Shrubs ..	7.6	10.1	25.1	3.0

* Centrosema was not satisfactorily established and this was virtually a natural cover treatment controlled by periodic slashing.

SECTION VI. MISCELLANEOUS

(1) Experiments set up on Estates under the Rubber Regulation Scheme

During the period of Rubber Regulation new planting was permitted for experimental purposes and nearly 9,000 acres were planted by the end of 1941. Most of these experiments were planted in accordance with the conditions contained in an agreement made between the Estates, the Controller of Rubber and the Institute. The total area under the supervision of this Division amounted to 5,500 acres, a figure which included nearly 200 acres of experiments on replanted land. About one-third of this total area was planted by estates in continuation of previous experimental work and our interest in this is only nominal.

By the time of the liberation most of the areas had reached tappable size and every effort has been made to restore these experiments and bring them into tapping so that the yields can be recorded. The revival of these experiments has been the biggest single item of work of the Division and has occupied much of the available time of the staff.

An analysis of the present position of the experimental areas is given in Table XXXII.

Some of the experimental areas were cut out for the growing of foodstuffs during the Japanese occupation and altogether 620 acres have been abandoned.

The records relating to these experiments were mostly lost during the occupation. In an attempt to replace them, a circular letter was sent in December 1945 to all estates with experiments requesting the loan of any records that had survived. A few estates were able to give us assistance but the majority had been even more severely looted than the Institute and were not able to find anything.

In most experiments it has been possible to reconstruct the layout in the field even when the plot corner marks have been destroyed. The principal exceptions to this are the clonal seedling trials; for unless the plot boundaries can be identified it is impossible to distinguish the families of seedlings from each other.

Whenever possible the original experiments are reconstructed. In some cases, notably in the time-of-opening and density-of-planting and thinning-out experiments the original schemes cannot be carried out and either new experiments

have been set up on the old experimental areas, or the original schemes have been modified.

By the end of 1948 fifty-nine experiments with which this Division is concerned were being tapped and the yields recorded over a total area of 2,515 acres. This figure includes a small number of experiments in which tapping has been temporarily discontinued.

TABLE XXXII *Field Experiments on Estates*
Summary of Experiments set up before the occupation

	Type of Experiment	Total No. of Experiments	Total acreage
1	Standard clone Trials ..	4	290.4
2	Subsidiary clone Trials ..	6	136.8
3	(a) R.R.I. Clone Trials (virgin land) ..	20	616.1
	(b) R.R.I. Clone Trials (replanted land) ..	5	81.2
4	Stock Experiments ..	3	116.0
5	Clonal Seedling Trials ..	18	748.6
6	Tapping Experiments ..	3	180.0
7	Density-of-Planting Experiments ..	4	400.2
8	Methods of Planting ...	1	56.0
9	Methods of opening Jungle land ..	1	150.0
10	Agency or Company Experiments in co-operation with R.R.I. ..	7	434.7
		72	3,210.0

We have to record our gratitude to the Managers and Staff of the estates on which these experiments are set up for continuing these experiments under most difficult conditions and providing us with many valuable records.

(2) Rubber Seeds for Oil Extraction

(i) A preliminary experiment was carried out in March in co-operation with the acting Senior Chemist, Department of

Agriculture, to determine what conditions are necessary for the collection of seed which would provide an oil of low free fatty acid content. The results of this investigation will be included in a separate publication.

(ii) A scheme was drawn up for studying the economics of large-scale collection of rubber seed on estates. Owing to the disturbed conditions in the country it was felt that no valid estimate of the costs could be made and the scheme was abandoned.

ADVISORY

CORRESPONDENCE

An analysis of the correspondence dealt with by the staff of the Division will appear in the Director's report.

Many enquiries were concerned with tapping young budded and seedling areas and great interest has been shown in full-circumference tapping not only on young rubber but also on mature rubber. In the latter case the enforced rest from tapping of four years has made possible the adoption of full-circumference tapping on large areas where it was previously impracticable. Many enquiries were also received on the choice of planting material, the conduct of estate experiments, general replanting and identification of clones.

PLANTING MATERIAL FOR SMALLHOLDERS

Preparations for the provision of improved planting material to smallholders were made in 1941. The work was resumed after the reoccupation as staff and labour became available, and during 1948 the staff of this Division undertook the collection of clonal seed for planting in the nurseries for providing seedling stumps.

Of the larger estates in Selangor, northern Negri Sembilan and southern Perak, 178 were asked to assist in the provision of clonal seed and to forward to us plans of their budded areas. Of the estates that responded 29 were found to have suitable budded areas and arrangements were made to purchase seed from them. Unfortunately it was a bad seeding year and only eleven of the Estates had sufficient seed to make collection worth while.

Altogether 1,700,000 seeds were collected from the estates which, with a further 575,000 seed from the Experiment Station, were sufficient to plant 25 acres of nursery on the

Experiment Station and four acres on various stations of the Department of Agriculture.

The quality of the seed was variable and below average. The seed collected in August and November to January was fairly good but the seed in September and October was poor and the quality again deteriorated towards the end of the season in February and March. The average germination throughout the year was 32.7 per cent.

This work placed a considerable strain on the already depleted staff of the Division and occupied one Botanist for nearly the whole of his time for six months and Senior Field Assistants for 117 days.

INTERVIEWS

Fifty-one planters and others visited the Division in 1946, one hundred and ten in 1947 and one hundred and three in 1948. Tapping and the choice of planting material were the subjects most frequently discussed.

VISITS

An analysis of the visits paid by the Staff is given on p.94.

PUBLICATIONS

The following publications were issued:—

Circulars (Botanical subjects)

- No. 20. "Reduction in Tapping Costs by Full-Circumference Tapping"—December 1945.
- 22. "Optimum stand per acre in Fields of Young Rubber"—September 1946.
- 23. "Poisoning of Rubber Trees with Sodium Arsenite before Replanting"—February 1947.
- 25. "Budgrafting without Waxed Budding Tape"—July 1947.
- 26. "Notes on Hedge Planting of Rubber"—July 1947.
- 28. "Clones of the R.R.I. 500 Series"—June 1948.

Advisory Leaflets

- B/AL. 18. The same as Circular 22—September 1946.
- 19. "Preliminary Note on the large-scale testing of R.R.I. clones of the 500-series"—September, 1946.
- 20. "Choice of Planting Material in 1946"—September 1946.

Member of Staff	Nature of Visit										Total		
	Research												
	General Advisory			Experiment Station			Estates						
1946	1947	1948	1946	1947	1948	1946	1947	1948	1946	1947	1948		
C. C. T. Sharp	3	27	5	20	17	24	18	18	3	41	52	32	
E. D. C. Baptist	2	4	—	8	16	5	18	34	19	28	54	24	
E. G. B. Gooding	—	5	1	—	99	68	—	21	14	—	125	83	
H. M. Burkill	—	—	42	—	—	5	—	—	—	—	—	47	
K. N. Kaimal	—	1	—	11	57	61	—	—	6	11	58	67	
T. V. Vaidyanathan	—	—	—	42	157	144	—	—	—	42	157	144	
Total	5	27	48	81	346	307	36	73	42	122	446	397	

21. "Instructions for the final pruning and treatment of the pruned surface of the snags of buddings made on large stocks"—June 1947.
22. "The Preparation of Nurseries"—July 1947.
23. "Suppliers of Clonal Seeds"—August 1947.
24. "Planting of Clonal Seed"—September 1947.
25. "Slaughter-Tapping by Tapping Upwards"—September 1947.

Botanical Memoranda

B/M. 36 (1948) "Multiple Stem Buddings"

37 (1948) "New Planting of Rubber by a Method of Jungle Clearing by Poison Girdling"

Lecture

A lecture on "The Choice of Planting Material" was given at Bentong to members of the I.S.P. (Pahang Branch) by C. C. T. Sharp.

Identification of Clones

The services of the Division's mandor for identifying clones in the nursery and the field have been in great demand and he has paid altogether 291 visits to estates and Government nurseries for this purpose.

C. C. T. SHARP,
Head of Botanical Division.

KUALA LUMPUR
June, 1950

REPORT FOR THE PERIOD JANUARY 1946 TO DECEMBER 1948

PATHOLOGICAL DIVISION

REPORT FOR THE YEAR 1946

STAFF

In consequence of the deaths of Mr. F. Beeley and Mr. R. P. N. Napper, and of the resignation of Mr. L. D. E. F. Vesey Fitzgerald, the Division has been deprived of its entire pre-war complement of senior officers, and is thus resuming its former functions under a considerable handicap. Provision has been made in the estimates for the appointment of a Pathologist, an Entomologist, and an Advisory Officer, but none of these vacancies had been filled by the close of the year.

Mr. K. P. John, Assistant Pathologist, continued to officiate as Officer-in-Charge until end of August, when the writer assumed duty as Head of the Division.

Mr. Hoh Choo Chuan, the Institute's Artist and Photographer, who was on duty throughout the year, successfully met all demands for his work in spite of the limitations imposed by a shortage of materials. No changes occurred in the Junior Staff, which had been restored to its pre-war establishment by the end of 1945.

The writer takes this opportunity of paying tribute to the able manner in which Mr. K. P. John performed his duties whilst in charge of the Division, and of recording his appreciation of the ready assistance tendered to him, on his assumption of office, by all members of the staff. His thanks are also due to the Senior Government Entomologist for valuable advice.

GENERAL

The work (begun at the end of 1945) of re-sorting files and experimental records, and of preparing inventories of residual stocks of equipment and apparatus, was completed early in the year. Unfortunately none of the orders for essential replacements, which were despatched to the United Kingdom on the conclusion of this stock-taking, has yet been delivered. The continued lack of several items of equipment needed for everyday use has been a great drawback.

The collection of cultures of pathogenic fungi, which was in existence before the war, has been overhauled, subcultures

being made from such of the original specimens as were still viable. Gaps in the collection are gradually being filled by new isolations.

Diseases of the Root System

CONTROL OF ROOT DISEASE IN RELATION TO REPLANTING

Although the effectiveness of the methods elaborated by Napper for the control of root disease had been fully recognised for some years before the war, there is evidence today of a tendency to question the worth of these measures. To some extent this change of attitude owes its origin to the fact that initial surveys, which had been carried out soon after the reoccupation of the country, suggested that root disease had made practically no headway in the replanted areas despite four years of neglect. Time, and perhaps more careful inspection, will show whether this view is correct. But in any case it seems to have been forgotten that considerable sums of money were expended in eradicating root disease from the majority of these fields before they were replanted.

Furthermore, it is of importance to remember that attacks by *Ganoderma pseudoferreum* seldom become outwardly visible until the trees are between ten and twelve years old, by which time heavy losses are unavoidable. And while special attention was paid to the control of this particular fungus before replanting, it is hardly to be expected that complete elimination of all sources of infection was achieved. Data derived from experiment B.K.1 show that, up to the end of the fourth year after planting, an average of two cases per acre of disease due to *G. pseudoferreum* occurred even in those plots (C and D) in which the old disease patches had been thoroughly dug over and all infected roots removed. It will be appreciated that had treatment been delayed until the presence of these cases was made evident by the death of the foliage, many additional trees would by then have contracted the disease.

The rising cost and scarcity of labour have in their turn helped to foster the growth of a more critical attitude towards the question of root disease control. That this should happen is not surprising, for a similar state of affairs has been known to occur during periods of financial stringency in the past. Nevertheless, one cannot avoid the conclusion that the tendency to curtail expenditure on disease control in times of stress is evidence of a general feeling of uncertainty regarding the ultimate value of such measures. It should be the

aim of this Division to dispel these doubts, but the insufficiency of the data that we possess makes it quite impossible for us to do this. As a result of Napper's work, we now have a fair idea of the *cost* of root disease control; but we know little of the influence of these measures on yield, and, through yield, on revenue.

While it is plainly desirable that some attempt should be made to close this gap in our knowledge, the best way of setting about the task is not so clear. However, taking all the circumstances into consideration, it seems that the only feasible method of approach is by way of suitably designed field experiments.

EXPERIMENTS ON ESTATES: (a) EXPERIMENTS LAID DOWN BEFORE 1941

For previous information regarding these experiments reference should be made to the Annual Reports for 1937-1940, and 1941-1945.

EXPERIMENTS B.K.1, B.K.2, AND L.P.1

A shortage of labour prevented any work being done in these three experimental areas during the year.

EXPERIMENT H.1

Two rounds of inspection and treatment (the 17th and 18th) were carried out in this experiment in 1946. Figures showing the incidence of disease up to the end of the ninth year after planting are given in Table I. The summary of the data relating to the first four years of the experiment (*i.e.* up to the end of 1941) has been taken from Table IV (*q.v.*) of the report for 1941-1945.

Reference to Table I shows that the superiority of treatment D (standard felling) has remained unchallenged; for, although no reliable cost data are available for a part of the period, it is evident from a consideration of the incidence figures for the last five years that this treatment held its place not only as the most effective, but also as the cheapest of the four studied.

The data summarized in Table I bring out in addition the notable fact that root disease had been virtually eliminated by the seventh year. When an attempt is made to analyse this result, one finds that it is impossible to separate the effect of the post-planting treatment from that of any particular pre-planting treatment. It is, of course, the case with all the

replanting experiments that the only incidence figures which are unaffected by the post-planting treatment are those for the first rounds of inspection. Nevertheless, the figures presented in Table I clearly suggest that the *rate* at which root disease can be eradicated is determined solely by the post-planting treatment. On the other hand, as the total number of cases which have to be dealt with will depend largely on the pre-planting treatment, it seems fair to assume that it is this treatment which mainly determines the *cost* of the process.

EXPERIMENT H.2

Two rounds of inspection and treatment (the 12th and 13th) were carried out in this experiment during the year. The number of cases of root disease which occurred annually in each of the four treatments up to the end of 1946 (the eighth year after planting) are given in Table II. It is to be seen from these figures that not only was the incidence of the disease significantly reduced by poisoning the old trees with sodium arsenite before replanting, but that it appears to have made little difference whether the poison was applied to the standing tree before felling (treatment B), or to the stump after felling (treatment C). A comparison of the results given by treatment C and treatment D (stumps not poisoned) shows that injection of the stumps with sodium arsenite reduced the number of cases of disease by about 40 per cent. Ring-barking (treatment A), which lost its leading position as a result of the extraordinary increase in disease which occurred in 1941, was without much effect. In the absence of further comparable cost data, it is as well to recall the conclusion reached on the basis of the first three years results, namely, that all four of the pre-planting treatments studied in this experiment are open to the objection that they led to a marked increase in the cost of the post-planting treatment through their failure to remove the old stumps.

It followed from the nature of the four clearing treatments employed in this experiment that the stumps of the original stand were left to rot *in situ* in all the plots. During the course of the annual rounds of treatment a record was kept of the number of these stumps which were found to be infected and were consequently removed. The figures thus obtained (which have been summarized in Table III) provide a *direct* record of the extent to which the pre-planting treatments have succeeded in their object of preventing the

TABLE I *Experiment H.1. Incidence of root disease up to the end of the ninth year after planting*

Treatment	Incidence of Disease					
	Total to 1941	1942 one round	1943 one round	1944 two rounds	1945 not recorded	1946 two rounds
A. Digging to 18 inches ..	65	4	5	1	not recorded	nil
B. Digging to 9 inches ..	67	3	2	nil		nil
C. Digging to 18 inches in 3 annual stages ..	124	4	6	nil		1
D. Standard eradication in disease patches. Healthy trees jacked out ..	59	3	2	2		nil
Totals ..	315	14	15	3	—	1
						348

TABLE II Experiment H. 2. Incidence of root disease (rubber trees only) year by year
up to the end of the eighth year after planting

Treatment	Incidence							
	1st year 1939 1 round	2nd year 1940 3 rounds	3rd year 1941 3 rounds	4th year 1942 1 round	5th year 1943 1 round	6th year 1944 1 round	7th year 1945 1 round	8th year 1946 2 rounds Total
A. Frill-girdling without poison	2	33	92	32	26	1	3	4 193
B. Frill-girdling with poison ..	6	45	50	7	18	1	3	1 131
C. Stumps poisoned ..	3	49	51	14	14	5	3	2 141
D. Stumps not poisoned ..	6	62	71	40	37	2	7	nil 225
Totals	17	189	264	93	95	9	16	7 690

development of sources of infection in the stumps. It is therefore of particular interest to compare these figures with those in Table II, and to note the correlation that exists, in the eight years' totals, between the incidence of disease in the young stand and of infection in the stumps. Moreover, from the closeness of this correlation it is reasonable to conclude that the stumps of the old stand provided the sole source of infection in this experiment; and that air-borne spores played no direct part in the spread of the disease among the young trees. This conclusion is of course in keeping with current views on the subject, but it is nevertheless of value to find the accepted opinion confirmed in this way by the results of an observation extending over a period of eight years.

EXPERIMENT G.1

The trees in this experimental area were destroyed by deer during the Japanese occupation.

EXPERIMENTS ON ESTATES. (b) EXPERIMENTS LAID DOWN IN 1941

At least four out of the six replanting experiments laid down in 1941 will have to be abandoned. In three cases (E.1, H.B.3 and G.2) the reason for this decision is inability to locate the plots. In the fourth case (H.B.2), the use of the experimental area for the cultivation of food crops has resulted in a reduction in stand which is so considerable as to deprive the experiment of any practical value. The future of the two remaining experiments is still uncertain. No plan has been found for H.B.4, and although there was at one time a hope that a copy might be forthcoming, there now seems small chance of this being realised. Reference has already been made to the fact that work was started on H.B.1 during the Japanese occupation. The position in regard to this experiment is discussed below.

EXPERIMENT H.B.1

In design this experiment differs radically from any of those which preceded it, its object being to compare, not the effects of pre-planting treatments, but various methods of post-planting control. Before the introduction of Napper's system of periodic tree-to-tree inspection, the presence of a diseased tree was generally determined either by its collapse,

TABLE III Experiment H.2. Number of old stumps found infected and removed year by year up to the end of the eighth year after planting

Treatment	Number of infected stumps						
	Total * to 1940	1941 3 rounds	1942 1 round	1943 1 round	1944 1 round	1945 1 round	1946 2 rounds Total
A. Frill-girdling without poison	39	71	14	11	1	3	nil 139
B. Frill-girdling with poison ..	56	29	1	5	1	3	nil 95
C. Stumps poisoned ..	52	31	2	7	5	3	nil 100
D. Stumps not poisoned ..	69	55	15	13	2	6	nil 160
Totals ..	216	186	32	36	9	15	nil 494

* Separate figures for 1939 and 1940 are not available.

or, less spectacularly, by the appearance of typical symptoms in its foliage. By the time these symptoms had become evident the tree was of course beyond treatment and was therefore removed, its root-system (together with the infected roots of neighbouring trees and suspected sources of infection) being completely eradicated by digging. With Napper's method, on the other hand, it is possible to detect infection early enough not only to prevent further spread of the disease, but to permit the successful application of curative treatment. The superiority of this method was not therefore in question, but it was no doubt considered desirable to demonstrate, by a comparison of the two methods, that the additional cost of the new system would be justified by the results.

A site was chosen for the experiment on a coastal estate, in an area that had been replanted towards the end of 1941. Standard methods had been employed in clearing the old stand, the stumps of healthy trees being removed by grubbers, and the root-systems of diseased trees by digging. A leguminous cover-crop was planted over the whole area. The experimental treatments proposed were as follows:

(1) New system, *i.e.* treatment of disease based on its detection by periodic tree-to-tree inspection.

(2) Old system, *i.e.* treatment of disease confined to obviously infected trees.

(3) Trees exhibiting obvious symptoms of disease removed, but eradication of infected roots restricted to a circular area 10 feet in diameter.

(4) As (3) but eradication restricted to a circular area 5 feet in diameter.

There is no record to show why treatments 3 and 4 were introduced, though it is evident that their interest lies in the fact that they would be even cheaper to adopt than treatment 2.

The experimental area was surveyed late in 1941 soon after it had been planted, and a plan was prepared which provided for the four treatments being replicated four times in randomized plots of two acres each. It was not, however, until eighteen months later, in April 1943, that an opportunity occurred of visiting the estate to mark out the plots on the

previously selected site. It was then found that most of the leguminous cover had been removed and its place taken by a mixed cultivation of tapioca, sweet potato, and ragi. A second food crop was planted in 1944. After this had been harvested, no further interest was taken in the area and it gradually became overgrown with grass. The rubber has suffered severely as a result of this ill-treatment, and its growth is at present much retarded.

Six rounds of inspection and treatment have been carried out in this experiment; four during the Japanese occupation (see Table XII of report for 1941-45) and two during the year under review. In December 1946 a census was taken of the existing stand. By comparing this with earlier records it has been made apparent that nearly 30 per cent. of the trees were missing before the first round of inspection was begun. There is naturally no means of determining in what manner these trees were lost, but that some have died as the result of root disease must be regarded as unquestionable. The uncertainty which surrounds their fate cannot fail to affect the reliability of any experimental results, since figures relating to the incidence of disease will always be open to the criticism that they are incomplete and consequently misleading. There seems to be no way out of this unfortunate dilemma, and it is a matter for serious consideration whether in these circumstances continuation of the work can be justified. A decision to abandon this interesting experiment will be reached only with the greatest reluctance, and the earliest opportunity will be taken of restarting it on a new site.

Secondary Leaf-fall

Before the war it was the custom for estates to report to the Institute any cases of secondary leaf-fall suspected of being due to *Oidium heveae*, at the same time forwarding specimens of leaves and flowers for confirmatory diagnosis. The more immediate demands of rehabilitation did not permit of this practice being renewed in 1946, and consequently it has been possible to form only a rough idea of the intensity and prevalence of this disease during the year under review. The weather during the period of refoliation was, however, unsuited to the development of any severe epidemic, and there is reason to suppose that nowhere in Malaya was anything but a mild attack experienced. A slight outbreak of secondary leaf-fall among the mature trees on the Experiment Station

was considered to be due more to infestation by mites than infection by *Oidium*.

By reason of the loss, during the occupation, of all the Institute's power dusting equipment, the purchase of a new machine in readiness for the next seasonal outbreak became a matter of some urgency. Enquiries made towards the end of the year disclosed that several of the leading manufacturers had not yet resumed production, and our choice was determined by the fact that only one firm was able to guarantee sufficiently early delivery.

Diseases of the Tapping Panel

MOULDY ROT (*Ceratostomella fimbriata*)

Mouldy rot became prominent during the closing months of the year in several districts, the activities of the pathogen being favoured not only by the very wet weather, but often by the presence of abnormally dense undergrowth. The employment of casual, contract labour has undoubtedly played a part in spreading the disease from smallholdings to neighbouring estates. Without a form of supervision far more elaborate than anything that can be provided these days, it is impossible to ensure that all tapping knives are properly sterilised before the day's task is begun; and many of these knives are used alternately on infected smallholdings and on estates.

The position in regard to the supply of approved fungicides was at first far from encouraging and many enquiries concerning this question were received. However, by the end of the year, seven of the twelve proprietary preparations in use before the war were again available on the local market. The increase in price over the pre-war figure has had a deterrent effect on their use by smallholders.

BLACK STRIPE (*Phytophthora palmivora*)

Few cases of black stripe were reported, which is rather surprising in view of the favourable conditions for its development which prevailed at the end of the year.

Stem and Branch Diseases

PINK DISEASE (*Corticium salmonicolor*)

This disease was active in stands of young rubber in several districts during the wet weather.

The methods employed in the control of pink disease have undergone no important change since they were first introduced about 30 years ago. Despite this long history of useful service they have recently come in for a certain amount of criticism. It is claimed, in the first place, that areas of young rubber, growing in districts notorious for the prevalence of this disease, have suffered so little harm during the war years that it is open to question whether the adoption of any measure of control is either justified or even necessary. There must be few, however, who would care to deny that past experience is entirely against a contention that pink disease can be left to pursue its course with impunity. There are, in fact, well authenticated records showing that neglect of the disease has led to an alarming increase in its incidence, and, what is perhaps more important, ultimately to the death of mature trees. It is possible, of course, that some of the clonal varieties that are now being grown are more resistant to the disease than were the unselected seedling trees, but we have as yet no evidence to support this hypothesis.

In so far as the control measures themselves are concerned, it is argued that by cutting away infected branches one is more likely to aggravate the disease than to cure it because this practice must inevitably result in the broadcasting of spores. While the danger to which this criticism refers is undeniably a real one, it should not be forgotten that it can be reduced to negligible proportions provided certain standard precautions are observed. These are, in brief, that no pruning should be carried out in wet weather, when the fungus is at its maximum activity; and that a diseased branch should be painted with a suitable fungicide *before* being cut out.

Termites

The increase in the population of *Coptotermes curvignathus*, that had occurred naturally enough after four years of freedom from any form of artificial control, led to a situation which at first caused some concern, particularly in areas of young rubber. The position was made more difficult by the lack of any suitable insecticides with which to treat the pest, and it was not until late in the year that supplies of some of the materials formerly used for this purpose became available—a notable exception being white arsenic, which continued to be unobtainable.

Observations made before and during the war had shown that a fairly satisfactory substitute for the latter substance

existed in the form of the locally produced "tin mine arsenic", and, with the object of procuring more precise information as to the best way in which to employ this, a further series of experiments were carried out on the Experiment Station by Mr. K. P. John. Two methods of application were compared. These were the "crater" and the "trail-injection" methods, both of which are fully described in the Annual Report for 1937, p.141. In the case of the former method it was found that three weekly applications of the arsenical dust at the rate of half-an-ounce per tree was sufficient to secure complete disinfestation of nine out of ten of the treated trees. It needed two further applications to obtain a similar result with the trail-injection method. With both treatments some damage to the bark occurred where the dust had cohered and fallen in excessive quantity, but in no case was this considered serious. Nevertheless, since the crude local product may vary in composition, and at times contain some of the arsenic in a form more soluble than the pure trioxide, it should always be used with more circumspection than is necessary in the case of imported white arsenic. With regard to the practical aspects of this experiment, the technique used would, it is thought, need some modification before it can be applied on a commercial scale, for the institution of weekly, or even fortnightly rounds of treatment over an extensive area would demand the employment of a force of labour larger than is usually available for such work.

Towards the end of the year, in preparation for laboratory tests on the toxicity of the synthetic insecticides, D.D.T. and Gammexane, a series of observations were carried out to determine the most suitable conditions for maintaining *Coptotermes* workers in captivity. During the course of this study the development of an unusually high death-rate in one of the treatments led to an examination which disclosed that the insects had been parasitized by an entomophthoraceous fungus. The causal organism was isolated on potato dextrose agar, and cultivated without difficulty on other standard media and on rice-bran. Its ability to parasitize and kill *Coptotermes* workers was established experimentally; a 100 per cent kill being obtained within 48 hours in trials in which the insects (maintained in petri dishes on sterile soil) were supplied with infected rice-bran as a source of food, the presence of the characteristic hyphae in the tissues of the insects confirming the cause of death. The mortality in the controls (fed on sterile bran) was three per cent during the same period.

It would obviously be unwise to infer from these results that the organism which has been isolated can be used effectively in the field for the control of *Coptotermes*. The fungus is indigenous, and it is therefore necessary to assume that the mortality caused by it under natural conditions is at least counterbalanced by the insect's normal rate of reproduction. Furthermore, it may well be that the workers' resistance to infection was lowered by the artificial environment provided by the experimental conditions. However, despite this unfavourable prospect work on the parasite will be continued until its potentialities have been thoroughly explored.

Cockchafers

Only one case of damage caused by cockchafer grubs has been reported during the period under review. It is a matter for question whether the absence of any additional records can be interpreted as meaning that this insect has largely ceased to be a pest. It was causing considerable trouble in certain districts in the years just preceding the war, and it seems more likely not that it has become innocuous but that the preoccupation of estates with the more urgent problems of rehabilitation has led to its activities being temporarily ignored.

Eradication of Lalang (*Imperata cylindrica*)

Not the least among the problems which faced planters on their return to this country was the question of how best to deal with a luxuriant growth of lalang which, favoured by four years of neglect, had overrun many hundreds of acres of young rubber. Systematic eradication by digging had kept this weed under effective control before the war, but today, with labour scarce and wages at more than double the former rates, it was proving quite impracticable in many cases to clear large areas in this simple but costly manner. There arose therefore an urgent demand for alternative and more economical methods.

Some years ago, Greig (*Malayan Agric. Journ.*, 1937, 25: 363) had shown that open land could be cleared of lalang relatively cheaply by eight weekly applications of sodium arsenite at the rate of 10-lb. to 60 gallons of water per acre. Nothing was known, however, of the possibility of using this method in stands of young rubber, and therefore early in the year it was subjected to trial in an appropriate area on the Experiment Station, under the supervision of Mr. K. P. John.

At the time that the work was begun, supplies of sodium arsenite were still unobtainable. A simple process for preparing this compound from the locally produced arsenical soot by treatment with caustic soda, or washing soda, had been worked out in 1941, and was described in the *R.R.I. Planter's Bulletin* for August of that year; but as the object of the proposed tests was to formulate a method of treatment capable of being adopted on a large scale, the prevailing shortage of both alkalis made the employment of this process undesirable, for it was essential that all the materials used should be readily available. Consequently, an attempt was made in the first instance to convert the "tin mine arsenic" into the potassium salt by boiling it with a lye prepared from wood-ash, but the elaboration required to produce solutions of known and constant strength led to this project being abandoned as unsuitable for use in the field.

The crude arsenical dust contains about 90 per cent. of arsenic trioxide, and can therefore be dissolved in boiling water to give solutions which retain nearly 4 per cent. of the oxide on cooling. Since this concentration was in excess of that needed for the purpose of the experiment, the use of an alkali to increase solubility was deemed unnecessary, and it was decided to carry out the tests with these easily prepared solutions of arsenious acid.

The site chosen for the experiment carried a stand of clone Pilmoor B.84, which had been planted as budded stumps in November 1941. A dense growth of lalang nearly five feet in height covered the whole area.

Observations were made on the effects of three rates of application each repeated at three intervals of time, namely, $7\frac{1}{2}$ -lb., 10-lb. and $12\frac{1}{2}$ -lb. of arsenic trioxide per acre applied at intervals of six days, nine days and twelve days. These nine combinations were laid down in duplicate, the area of the unit plot being one-sixtieth of an acre. The arsenious acid solutions, which were prepared as required from a saturated stock solution, were applied by means of a pneumatic knapsack sprayer at a rate of 60 gallons per acre (*i.e.*, one gallon per plot). The treatments were continued for about fourteen weeks. It was found that the lalang could be brought under control most economically by about eight applications at the rate of 10-lb. of arsenic trioxide to 60 gallons of water per acre, repeated at intervals of nine days. However, neither this treatment nor any of the others succeeded in eradicating the weed entirely, but the few viable rhizomes which remained

were easily dealt with by digging. Some injury was caused where the spray fell accidentally on to immature bark.

Root Nodule Bacteria

Naturally, nothing remains of the stock of tested cultures of *Rhizobium* which was being maintained before the war for distribution to estates. Fresh isolations have been made from nodules of *Centrosema pubescens*, and these were in the course of being tested at the end of the year.

Advisory Work

The appendix to the Director's report will show that 202 letters were despatched from the Division during the year. Only 22 specimens were sent in for examination. The graduate staff of the Division paid five visits to estates and small-holdings and 22 visits to the Experiment Station. Interviews at the Institute totalled 20.

R. A. ALTON

Head of Pathological Division

KUALA LUMPUR,
7th May, 1947.

REPORT FOR THE YEAR 1947

STAFF

Dr. A. Newsam arrived in Kuala Lumpur and assumed duty as Entomologist on the 5th April, 1947.

The post of Advisory Officer has been filled by the appointment of Mr. F. W. Hutchison, who is expected to take up his duties early in 1948.

The post of Pathologist still remains vacant.

Mr. K. P. John, Assistant Pathologist, was absent on long leave from the 15th January until the 3rd September, 1947.

Mr. Hoh Choo Chuan, Artist and Photographer, proceeded on long leave on the 16th September, 1947. Mr. Chan Tham Yew, Assistant Artist and Photographer, acted in the senior appointment from that date.

I. Diseases of the Root System

The Root Disease Problem in "Jap-felled" areas. A root disease problem of some magnitude has arisen in connexion with the replanting of the areas that were cut out during the Japanese occupation. These areas had been cleared with the object of providing land for the cultivation of food crops, and consequently no attempt was made to remove the stumps left behind after felling the original stand. A high proportion of these stumps (particularly on the heavy coastal soils) have since become thoroughly infected with *Fomes lignosus*, and estates have naturally been much concerned to know what steps they should take to eliminate such dangerous sources of infection before starting to replant. Unfortunately there is only one satisfactory way of dealing with these stumps and that is to remove them, for neither of the alternative methods of treatment open to consideration (poisoning and isolation) offer much promise. All the evidence in our possession goes to show that little or nothing is to be gained by injecting sodium arsenite into stumps that have been rotting in the soil for two or more years; and isolation can at the best have only a limited value seeing that a large part of each diseased root system must of necessity remain outside the trenches. But since the cost of eradicating stumps by manual labour is nowadays quite prohibitive, the problem of freeing these areas from root disease before they are replanted must be regarded as virtually insoluble, unless conditions are such as to permit the employment of mechanized methods.

Eradication versus Isolation. The relative merits of eradication and isolation as methods of controlling root disease, particularly in stands of young to medium-aged rubber, have been the subject of many enquiries. Isolation tends to be favoured because of its lower initial cost, but this is considered, in the opinion of the writer, to be a short-sighted attitude. Not only is isolation at the best only a palliative, but it is quite unsuited for use in stands which are not yet old enough for their root-systems to have expanded and occupied the whole extent of the soil. Moreover, effective isolation entails a biennially recurrent charge for maintenance the amount of which may almost equal the initial outlay, whereas expenditure on eradication may be expected to decrease rapidly and progressively year by year.

Taking the long view there seems little question that a regular programme of eradication is the best policy to adopt; for, apart from the obvious advantage of reducing the annual

losses from root disease to a minimum in an existing stand, it would appear to be more logical to spread the cost of this operation over a term of years than to defer the work until the time comes for replanting, when the whole accumulation has to be dealt with in the space of a few months. It is a matter for question, however, whether these arguments are likely to carry much weight at a time when the majority of estates are proposing to clear land for replanting by frill-girdling and poisoning, regardless of whether the roots of the old trees are diseased or healthy. This practice, which of course completely ignores Napper's finding that poisoning cannot be relied upon to neutralize active sources of infection, is justified on the grounds of economy. Whether the future will prove this to have been a false economy or not must remain to be seen, but it is a fair assumption that the circumstances that have led to the adoption of such a policy are unlikely to favour the reception of advice which is based on a belief that every opportunity should be taken of freeing land from root disease before it is replanted.

The Freedom from Disease of Pre-war Replantings. In the days of the controversy between the advocates of "clean-weeding" and those of "forestry methods", the freedom from root disease of many smallholdings was frequently attributed by the latter to the presence of a natural undergrowth. Actually, the example chosen was an unfortunate one, for the incidence of root disease is low in a typical smallholding for the same reason that it is low on certain estates, namely, because the land had been cultivated for many years with other crops before being planted with rubber. Nevertheless a certain amount of evidence indicating that the incidence of root disease does tend to be reduced in the presence of a ground cover (irrespective of whether the latter consists of introduced leguminous plants or of an indigenous undergrowth) was obtained before the war (*J. Rubb. Res. Inst. Malaya* 1932, 4, 5-33; *Ann. Rept. R.R.I.M.* 1940, p.97; *Ann. Rept. R.R.I.M.* 1941-1945, p.51). Perhaps on the strength of these findings, but more probably because of the continued survival of the earlier tradition, a school of thought has arisen which attributes the relative freedom from root disease of many of the pre-war replantings partly to their invasion by natural undergrowth, but more particularly to the circumstances that the soil in these areas has remained undisturbed for a period of years.

Although in the opinion of the writer there is not the slightest question that the satisfactory condition of these

replantings is to be credited more to the adequacy of the methods employed in removing the old stand than to any other factor, the latter hypothesis is worthy of some attention in view of its kinship with the suggestion once put forward by Napper (*J.R.R.I.M. loc cit.* p.18) that it might be possible to rejuvenate a staled culture of *Fomes lignosus* by disturbance of its environment. It is proposed, therefore, to subject it to the test of experiment as soon as an appropriate opportunity occurs.

Experiments on Estates. (a) *Experiments laid down before 1941.* It had been the intention to carry out a final round of collar inspection in four out of the five experiments that had been laid down in 1937 and 1938. The fifth experiment (L.P.1) was omitted from the programme, for judging from its past history it seemed unlikely to yield any useful information. But as the estate on which experiments H.1 and H.2 were situated was unable to spare the necessary labour, and as the site of B.K.2 could no longer be located, B.K.1 ultimately proved to be the only area on which it was possible to execute this plan. The results yielded by this final round of inspection are included in Table IV, which has been drawn up to show the complete history of the incidence of root disease in this 80-acre replanting for the first ten years of its existence. The data have been summarized in three groups: (a) those recorded by the regular rounds of inspection carried out during the four years preceding the Japanese attack; (b) those recorded by the single round of inspection carried out during the first year of enemy occupation; and (c) those recorded (five years later) by the final round of inspection carried out during the year under review.

Perhaps the most interesting point brought out by this table is that of the total of 1,162 cases of disease reported during the course of the experiment, no less than 93 per cent. occurred during the first five years. Lest there should be thought to be something abnormal about these figures, and that the decline in incidence during the second five years is in some way bound up with the fact that no steps were taken to treat the disease during that period, attention is drawn to the results obtained in experiments H.1 and H.2. These are summarized in Tables I and II of the report for the year 1946, but for ease of reference the relevant facts have been re-tabulated below:

TABLE IV Experiment B.K. 1. Number of cases of Root Disease recorded up to the tenth year after planting

Treatments	Fomes lignosus				Ganoderma pseudoferreum				Fomes noxius				Ustulina zonata				Grand Total
	1937-41	1942	1947	Total	1937-41	1942	1947	Total	1937-41	1942	1947	Total	1937-41	1942	1947	Total	
A	63	5	1	69	45	5	1	51	14	3	5	22	5	—	2	7	149
B	85	2	—	87	64	1	2	67	9	1	—	10	10	—	11	21	185
C	123	1	—	124	26	2	—	28	18	—	1	19	5	—	4	9	180
D	142	1	—	143	29	2	1	32	18	3	4	25	4	1	5	10	210
E	146	2	—	148	33	—	—	33	13	3	2	18	3	—	10	13	212
F	103	5	3	111	67	10	8	85	8	—	2	10	3	—	17	20	226
Total	662	16	4	682	264	20	12	296	80	10	14	104	30	1	49	80	1,162

TABLE V *Relation between Incidence of Root Disease
and Age of Stand*

Experiment	H. 1	H. 2
Period covered by the record	The first 9 years of growth. 1937-46	The first 8 years of growth. 1938-46
Years in which annual rounds of treatment were carried out	Every year except 1945.	Every year.
Total cases ..	348	690
Proportion of cases occurring in the first 5 years.	94%	95%

These observations plainly have an important practical bearing, since they suggest that expenditure on root disease control may safely be curtailed from the sixth year onwards—provided that the previous treatment has been based on regular tree-to-tree inspection. This proviso is, of course, essential in view of the conditions under which these results were obtained. But it must be admitted that with the evidence at present at our disposal it is impossible to say how much of this rapid decline in the incidence of disease after the first few years of growth is to be credited to the method of control that was employed, and how much to an increase in the disease-resistance of the host. That we are still in this state of uncertainty, despite all the work that has been done on this subject, is due to the fact that no untreated plots were included in any of the experiments from which these data are derived. While this may now appear to be an unfortunate omission, it is to be remembered that it was not the purpose of these experiments to study the problem of disease control in a young stand, but to determine the most economical way of ridding old rubber land of root disease before it is replanted. In so far as this latter problem is concerned, the additional data presented in Table IV can add little to the conclusions drawn (in previous reports) from the first four years' results of experiment B.K.1, for the very good reason that the essential cost figures are lacking. However, the fact that another 18 trees have become infected with *Ganoderma* in the stump-poisoned plots (F) since 1941 compared with a mean number of 5.3 for all treatments may be regarded as further evidence of the ineffectiveness of poisoning as a means of controlling active sources of infection, *i.e.* those existing at the time of felling.

Before leaving Table IV it should be noted that the decline in incidence that occurred from the sixth year onwards applies only to cases of disease caused by the three major parasites (*Fomes lignosus*, *Ganoderma pseudoferreum* and *Fomes noxius*), and that the incidence of *Ustulina zonata* has not only shown no general tendency to fall during the last five years, but has actually been on the increase in treatments E and F.

Experiments on Estates. (b) *Experiments laid down in 1941.* By the end of 1946 it had already been decided (for reasons given in the report for that year) that it would be necessary to abandon at least four out of the six replanting experiments that had been started by Napper in 1941. It has now become apparent that the remaining two (H.B.1 and H.B.4) must suffer a similar fate. In so far as H.B.1 is concerned, further consideration has shown that, much as we regret the decision, there is in fact no way of overcoming the difficulty created by the incompleteness of the existing record. And although, contrary to all expectation, a plan for H.B.4 did eventually come to light, it proved to be so lacking in detail as to be useless.

Observations on D-D. (Dichloropropane-dichloropropylene). Experiments carried out during the last five or six years in Hawaii and the United States have shown that D-D is an effective soil fumigant for the control of nematodes and other soil-borne pests. It is also highly phytotoxic, and on this account the idea arose that if it were injected into the soil preparatory to replanting it might serve to neutralize any centres of infection that would otherwise be left behind by the old stand. It was evident, however, that for this plan to achieve any measure of success the D-D vapour would not only have to be toxic to the root parasites, but capable of diffusing through an infected root in order to destroy the internal mycelium. An investigation was therefore started to determine what prospects there were of these two essential conditions being fulfilled. The ability of the D-D vapour to inhibit the development of the three major parasites (*Fomes lignosus*, *Ganoderma pseudoferreum* and *Fomes noxius*) when these were grown on the surface of agar plates was established quickly and beyond doubt; but the experiments set up to determine whether this vapour is able to kill the organisms when they are present within the tissues of a diseased root developed an unexpected complication. Irrespective of whether the infected roots were exposed to the vapour in vessels plugged with cotton wool, or when buried in soil, the effect of the treatment appeared so to stimulate the growth of a

common soil saprophyte (*Trichoderma viride*) that it tended to overwhelm the parasite. It is still a matter for question whether this result means that the parasite had been killed, or merely that its resistance had been so reduced that the *Trichoderma* could no longer be held in check; but the fact remains that isolations made from infected roots that were subjected to the D-D vapour almost invariably yielded not the parasite but cultures of *Trichoderma*. On the other hand no difficulty was experienced in recovering the parasite from roots that had been used as controls. The known antagonism of *Trichoderma* to *Rhizoctonia solani* and other soil-borne plant pathogens lends a particular interest to these observations. Indeed, one is inclined to wonder whether there is here a suggestion that the activities of beneficial soil antagonists might be stimulated by appropriate chemical means.

Observations on the origin of certain sources of infection. The way in which the roots of rubber trees that are apparently healthy at the time of felling become invaded by *Fomes lignosus*, and thus converted into what are frequently dangerous sources of infection for the new stand, is not yet understood. Two suggestions have been put forward in the past: one that the cut surface of the stump becomes infected through the agency of air- or insect-borne spores; and the other that the fungus is present in the roots in a dormant condition and springs into activity when the resistance of the host tissue is lowered by severance of the stem. No convincing evidence has ever been produced in support of either hypothesis, but much weight has been lent to the second one by the demonstration (Leach, R., *Trans. Brit. Mycol. Soc.* 1939, 23, 320-329) that *Armillaria mellea* may lie dormant in localized lesions in the roots of certain forest trees in Nyasaland; and for this reason observations are now being carried out in one of the 20-year-old stands of rubber on the Experiment Station to see whether the same thing holds true for *Fomes lignosus*. The procedure that has been adopted is simple. Large laterals are exposed, severed by a saw cut, and then re-covered with soil. Once a month a representative sample of the severed roots is removed for detailed examination in the laboratory. So far nothing to suggest that *Fomes lignosus* or either of the other two major parasites can lie dormant in a rubber root has yet been observed.

II. Diseases of the Tapping Panel

(1) MOULDY ROT (*Ceratostomella fimbriata*)

General Observations. Owing to the abnormally wet weather experienced in 1947 there was little or no respite from mouldy rot in some parts of the country during the whole course of the year. Many estates complained that they were finding it extremely difficult, if not impossible, to bring the disease under control. Enquiry usually showed that most of this trouble could be attributed to one or more of the following causes: failure to restrict undergrowth to reasonable proportions; infrequency of the fungicidal applications; and failure to enforce the proper disinfection of the tapping knives. While it is only too evident that all these shortcomings may be traced back to circumstances over which the planter himself can exercise no sort of control, namely, shortage of staff and high cost of labour, it is nevertheless unreasonable for anyone to suppose that the disease can be checked despite them. Another factor which adds to the planter's difficulties is also a product of the times: the proper way of dealing with an intractable case of mouldy rot is to take the infected tree out of tapping and treat it whilst it is being rested; but, faced as they are with an insistent demand for maximum production, many properties can no longer afford to adopt this method. There cannot be the slightest doubt that it is to this combination of circumstances, and not (as is sometimes suggested) to a general decline in the efficacy of the approved fungicides, that one must ascribe the fact that the control of mouldy rot is becoming a far more troublesome problem today than it was before the war.

Development of a Laboratory Method for the Preliminary Evaluation of Fungicides. An attempt is being made to develop a laboratory method for the preliminary testing of fungicides likely to be of value in the treatment of mouldy rot. The method at present in use consists in seeding agar plates with a suspension of spores of *Ceratostomella fimbriata* and then spraying the resulting colonies—24 to 48 hours later—with the fungicides under test. Efficacy is judged by comparison, (a) with control plates, and (b) with plates treated with one of the approved fungicides. This is in effect a test of therapeutic value. Earlier tests of prophylactic value—made by seeding the plates *after* they had been sprayed—were discontinued as being of less practical interest. So far the results

obtained by these tests have not been entirely confirmed in the field. Although this discrepancy is no doubt due in part to defects in the laboratory technique, some of it must be referred to the difficulty of assessing results in the field with precision. It is hoped with time to improve both methods.

Field Trials of Synthetic Fungicides. The following synthetic fungicides have been tested for use against mouldy rot in experiments laid down on heavily infected smallholdings:—ferric dimethyl-dithiocarbamate (Fermate), zinc dimethyl-dithiocarbamate (Zerlate), zinc ethylene bis-dithiocarbamate (Dithane Z-78), tetrachloro-para-benzoquinone (Spergon) and phenyl mercury fixtan (P.M.F.). All had previously been subjected to phytocidal (bark-burning) tests. The maximum concentrations at which they were used—both in the phytocidal and subsequent fungicidal tests—were determined by the manufacturers' recommendations. The test plots were treated every tapping day (*i.e.* every day) for 28 days, the fungicides being applied by means of a pneumatic hand sprayer. Untreated controls and plots treated with an approved fungicide were set up for comparison. Spergon at 1 per cent. and P.M.F. at 0.4 per cent. showed some promise; the carbamates (Fermate, Zerlate and Dithane Z-78) all at 0.2 per cent. were ineffective. Neither Spergon nor P.M.F. approached the level of effectiveness of the approved fungicide, which brought the disease completely under control after 14 days' treatment. The fungicidal efficacy of these synthetic fungicides can no doubt improved by increasing their concentrations, and in 1948 it is proposed to test them again at strengths limited only by phytotoxicity and considerations of price.

Field Trial of V.P. 2295-IA. V.P. 2295-IA is a viscous petroleum grease that has been recommended by its manufacturers for the treatment of diseases of the tapping panel. Before the war, a mixture consisting of a similar substance dissolved in Solar Oil and containing 10 to 20 per cent. of tar oil as a fungicide was finding a use in Sumatra as a preventive of black stripe.

For our trial of this grease a site was selected on an estate in Selangor where the incidence of mouldy rot was unusually high. The original intention had been to run the experiment for a maximum period of 28 days, but failure of the contract tappers to adhere to the plan for regular alternate-daily tapping so vitiated the earlier observations that it was found necessary to carry on for a further four weeks. The 2295-1A was tested as a 50 per cent. solution in Diesoline and

as a 50 per cent. solution in a mixture containing 45 parts of Diesoline and 5 parts of a proprietary wood-preservative. Both preparations appeared to bring the disease under control after nine alternate-daily applications, but the consistency of the mixture was such that it was by no means certain whether the fungus had been killed or merely rendered invisible. It was hoped that it would be possible to clear up this point by examining the trees two or three months later. However before this could be done, nearly all the panels that had been painted with the 2295-IA mixtures were severely damaged by wild pig, thus rendering a further examination useless. The question of the fungicidal value of the two preparations is therefore still in doubt. If possible, both will be given a further trial next year. But, since an analysis (carried out by the Chemical Division) of samples of scrap collected from the test plots has shown that both mixtures have, as was rather to be expected, a very deleterious effect on this material, it is already evident that even should they prove to be effective against mouldy rot it would be inadvisable to employ them except in cases where the infected trees are to be taken out of tapping.

Field Trial of the Approved Tar-acid Emulsions. In view of the fact that a number of adverse reports had been received concerning the performance of certain of the approved water-miscible fungicides, eight of these proprietary preparations were subjected to a comparative trial on a heavily infected smallholding. All were tested at a concentration of five per cent. in water. Since this was in the nature of an exploratory test, which it is proposed to repeat next year, it is not considered desirable to publish the results at this juncture. It may, however, be mentioned that whereas some of these preparations succeeded in bringing the disease under control after seven applications others failed to do so after twenty-eight; and that efficacy was found to bear no relation to price.

(2) BLACK STRIPE (*Phytophthora palmivora*)

In spite of the unusually wet weather experienced in many parts of the country only one outbreak of black stripe was brought to notice during the period under review. This occurred on an estate in the Sungei Siput district and assumed rather serious proportions. Among a number of clones which were involved in this attack, B.D.5, Avros 49 and Pilmoor A.41 appeared to be the most severely affected.

III. Secondary Leaf-fall

Secondary Leaf-fall in rubber may be briefly described as a disease characterized by the shedding of immature leaves, which typically becomes prominent during periods of annual refoliation. Previously it has been customary to attribute this disease exclusively to the attacks of *Oidium heveae*, but observations carried out during the course of the year have left little doubt that at least two other organisms—*Gloeosporium alborubrum* and *Hemitarsonemus latus* (the yellow tea mite)—are also concerned in its causation. It is still probably correct to regard *Oidium heveae* as the most injurious of these three parasites; though, seeing that they may occur on the leaves not only separately but also in all the four possible combinations, it is actually no easy matter to assess their relative importance.

Observations on the Annual Outbreak. Wintering started (as is normal) in the extreme north of the Peninsula early in January, and was coming into evidence over most of the country about a month later when its progress was checked almost everywhere by a prolonged spell of wet weather. As a result refoliation was much delayed and in many districts the new canopies were not fully developed until quite late in May.

Outbreaks of secondary leaf-fall are known to have occurred in every State and Settlement in the Union other than Trengganu and Kelantan. The attack appears on the whole to have been mild, but a case where infection was rather severe was encountered in a group of smallholdings in Ulu Selangor.

Early in the year proprietors and managers of estates throughout the country were requested, through the medium of the press, to report any cases of secondary leaf-fall coming to their notice and to forward specimens for diagnosis. Between March and May, fifty-nine estates responded to this request. These were distributed as follows:—

TABLE VI *Distribution of Estates reporting Secondary Leaf-fall*

State or Settlement	Number of Estates
Kedah ..	1
Kelantan ..	nil
Trengganu ..	nil
Perak ..	12
Province Wellesley ..	nil
Selangor ..	7
Negri Sembilan ..	21
Pahang ..	2
Malacca ..	4
Johore ..	12

The significance of the data recorded above must be regarded as questionable, since there is good reason to believe that secondary leaf-fall occurred on many more than the fifty-nine estates that reported it. This is a most regrettable state of affairs; for our ability to detect any change in the character of the disease, such as might result from an increase in virulence of one of the existing pathogens or from the introduction of a new one, is largely dependent on the information provided by these estate returns.

Examination of the specimens which were forwarded for confirmatory diagnosis yielded the following results:—

TABLE VII *Cause of Injury in 59 cases of Secondary Leaf-fall*

Parasite	Number of cases
Oidium ..	24
Hemitarsonemus latus ..	12
Gloeosporium alborubrum ..	2
Oidium and Hemitarsonemus ..	19
Oidium and Gloeosporium ..	1
Gloeosporium and Thrips ..	1

The above table shows that in less than 50 per cent. of the cases examined could secondary leaf-fall be attributed to *Oidium heveae* alone. In some of the cases where the fungus occurred together with the mite there was every indication that the latter was the major cause of the injury.

IV. Leaf Diseases of Young Plants

(1) BIRD'S EYE SPOT. (*Helminthosporium heveae*)

Bird's Eye Spot became prominent in seedling nurseries all over the country towards the end of the year. Some of the outbreaks which occurred in Selangor and Johore were particularly severe and led to much defoliation.

This disease appears to have undergone a considerable change in character since it was first observed in Malaya some forty years ago. From being, for many years, an affection of such minor importance that it rarely achieved the distinction of separate mention, it has gradually become what must today be regarded as the most serious of all the leaf diseases affecting young plants in this country. It is

true that even now it seldom kills a plant, but the repeated defoliation which is characteristic of heavy and continuous attacks can so seriously retard the growth of seedlings (both in the nursery and in the field) that the result is not infrequently the complete disorganisation of a budding programme. It is possible, of course, that it is largely because of its ability to interfere with the timing of planting operations that bird's eye spot has been attracting greater attention in recent years. In the days before budgrafting had become a general practice, retardation of the growth of nursery seedlings would not, perhaps, have been such a critical matter.

A wide difference of opinion has existed as to the influence of weather on this disease; some holding that the activities of the pathogen are favoured by long spells of dry weather, and others, by periods of heavy rain. The outbreak which occurred during the year under review originated and grew to epidemic proportions during the main wet season.

Once *Helminthosporium heveae* has become firmly established in a nursery it is an extremely difficult matter to bring it under control. The recognised form of treatment is to dust the plants with sulphur at approximately weekly intervals, but the best that can be said for this practice is that it may reduce the incidence of the disease sufficiently to prevent serious defoliation. With the object of exploring the possibilities of finding a more effective method of control, the following fungicides and insecticides are now being tested in an experiment that was laid down in a large seedling nursery at Sungei Buloh at the end of November:—

Sprays: *Perenox* (50% Cu as cuprous oxide) at 2 lb. to 100 gallons; *Wettable Sulphur* at 2lb. to 100 gallons; *D.D.T.* as a 0.1% emulsion.

Dusts: *Triocide* (2.5% Cu as oxychloride, 3% D.D.T., 88% sulphur); *Perelan* (17.5% Cu as cuprous oxide); *De De Tane* (5% D.D.T.); *S. S. Sulphur*.

The inclusion of preparations containing D.D.T. was considered desirable in view of past observations suggesting that nursery leaf diseases are often a complex of insect and fungus attack.

(2) *Gloeosporium alborubrum*

Judging by observations carried out during the last quarter of the year, *Gloeosporium alborubrum* would appear to be a factor of negligible importance in the causation of leaf

disease in nursery seedlings. This is not, however, its position in relation to young budgrafts growing in multiplication nurseries. Such material may at times be badly defoliated by the attacks of this fungus. There seems, indeed, to be something selective about the pathogenicity of *Gleoesporium alborubrum*. As one of the parasites responsible for secondary leaf-fall it commonly occurs in association with *Oidium heveae* or the yellow tea mite, but with certain high-yielding clones, such as B.D.5, S.R.9 and Tj.1, it is often the only organism—or at least the most prominent organism present.

(3) OTHER FUNGI

A leaf disease bearing a superficial resemblance to bird's eye spot, encountered in a seedling nursery in Selangor, was found to be associated with a fungus which is regarded, provisionally, as a species of *Spondylocadium*. The spots were smaller than those normally produced by *Helminthosporium heveae*, the largest not exceeding 1.5 mm. in diameter.

A species of *Colletotrichum*, differing from Petch's *C. heveae* in the length of its setae and in the width of its spores, has been observed occasionally on seedling leaves suffering from a heavy attack of the *Helminthosporium*.

V. Defence against South American Leaf Blight

Since it had become evident that the continued freedom from South American leaf blight (*Dothidella ulei*) of the Far Eastern rubber cultivations was now being threatened by the increasing speed and volume of modern air traffic, a memorandum was prepared towards the end of the year drawing attention, *inter alia*, to the fact that some form of international action was needed to prevent the introduction of this dangerous disease into the South East Asian region.

VI. Diseases of the Stem

PINK DISEASE (*Corticium salmonicolor*)

An increase in the incidence of pink disease in stands of young rubber was reported from several localities during the early part of the year. In some cases where regular treatment had not been carried out, the infection had spread to the lower branches and even to the main stem.

VII. Injuries of Non-Parasitic Origin

INTERNAL FISSURES. Cortical fissures resembling those described by Sutcliffe in 1930 (*J. Rubb. Res. Inst. Malaya* 2, 12-15) have been observed on the tapping panels of a number of trees of clone Glenshiel 1 growing on a coastal estate in Selangor.

HEAT INJURY. Injury to the cortical tissues of the stem caused by the heat generated by a rapidly decomposing green mulch is considered to have been responsible for the death of nursery seedlings in Kelantan and of transplanted seedlings (pencil stumps) in Selangor. In both cases the injured tissues were subsequently invaded by *Botryodiplodia theobromae*. The stems of the nursery seedlings exhibited lesions that were indistinguishable from those which develop as a result of sun-scorch, an affection caused by reflection of solar heat from the surface of the soil. That sun-scorch was not the cause of the lesions in this case was evidenced by the fact that they had occurred in a nursery where the plants had been protected both by overhead shade and by a mulch.

SODIUM ARSENITE INJURY. Several cases have occurred where damage has been caused to the stems and exposed roots of young trees through direct contact with a sodium arsenite spray that was being used for the eradication of lalang (*Imperata cylindrica*). Two forms of injury have been observed, their difference depending on the depth to which the poison has penetrated. In one, which is characterized by a copious exudation of latex, the damage involves the whole thickness of the bark and the outer layers of the wood. In the other, which is fortunately the more common type, the damage is confined to the peripheral tissues of the cortex; and frequently the only indication that it has occurred is the appearance of a blackish vertical streak on the surface of the bark. When deep penetration has taken place, the whole thickness of the bark dies over a restricted area and an open wound is formed, which, until the dead bark has fallen away or been removed, appears merely as a depression on the surface of the stem. Where the injury has been superficial, a cork cambium develops beneath the affected tissues with the result that these are eventually sloughed off exposing normal bark.

Seeing that the full extent of the damage that the poison is capable of inflicting will generally have been reached long before it is realised that any injury has been caused, routine treatment of an affected tree is to be deprecated; for haphazard cutting and scraping will only have the effect of delaying the

natural processes of recovery that have already been set in train. An exception to this will occur when it is apparent that the poisoned bark is attracting boring beetles. In such cases, the same form of treatment as is used to protect fire-damaged trees from these insects must be applied without delay. Apart from this, the only action that is necessary is to treat the open wounds resulting from deep penetration as soon as their limits have become clearly defined.

VIII. Termites

Coptotermes curvignathus Holmgr., which is the only species of white ant known to be capable of penetrating living rubber trees in this country, is without question the most important pest that the industry has to deal with. Despite all the work that has been done on this insect since it first attracted attention nearly 50 years ago, no fully satisfactory method of controlling it has ever been evolved. That this should be so is due almost entirely to the inaccessibility of the central nest. Existing procedures are effective in driving termites away from a newly-attacked tree, but the colony is not destroyed, and treatment is invariably followed by a fresh attack on the same or an adjacent tree. Thus control measures entail regular inspection and treatment of infested areas, with no prospect of the incidence of attack becoming so reduced that they may be discontinued.

Biological Control. The difficulties inherent in chemical control measures led to consideration being given to the possibility of evolving a method of biological control based on the parasitic fungus which had been isolated from *Coptotermes curvignathus* workers brought into the laboratory for experimental purposes in 1946 (see p.108). Observations on the mode of action of this organism (which we now believe to be a strain of *Conidiobolus villosus* Martin) were made on termites maintained in Petri dishes on substrates of moist soil or filter paper, the fungus being introduced in the form of a culture on rice bran. It was found that death ensued within twenty-four hours of the termites coming into contact with an actively growing source of infection from which conidia were being freely ejected. A few hours after all movement had ceased conidia were formed externally over the body, particularly from the head and thorax, the conidiophores breaking through the softer regions of the cuticle between joints of the antennae, around the mouthparts and through intersegmental membranes. Infected termites could be used to infect others, but in this

case the progress of the disease was slower than when a bran culture was employed.

Following these observations several attempts were made to infect wild colonies of *C. curvignathus* with the fungus, the hope being that the infection would be carried back to the central nest in the bodies of diseased workers, with consequent destruction of the entire colony. Three methods of introduction were tried: the first, crumbs of a bran culture were introduced at several points into the earth runs on a tree trunk; the second, a water suspension of conidia was poured into the earth runs; the third, captured workers were exposed to infection in a Petri dish and then returned to the colony. None of these methods was successful.

The cause of the failure of the fungus in these field tests was sought in the laboratory. The possibility that death of the laboratory termites had been due to poisoning from a by-product of the fungus was excluded by demonstrating that a culture killed by heat—half an hour at 50°C.—was rendered harmless. Moreover soldiers isolated from workers, and therefore unable to feed, could be infected by bringing them into contact with a bran culture and died faster than the controls. The effect of temperature on the growth of the fungus was not examined experimentally as it was considered that laboratory temperatures, at which infection took place readily, could not be sensibly different from those obtaining in the termites' microclimate. In observing the effect of humidity it appeared that the fungus could tolerate drier conditions than the termites; both organisms were found to thrive best near saturation point. The possible influence of hydrogen ion concentration was investigated, and certain differences found between the values for soil and for the earth runs and galleries composed from it. The conidia of the *Conidiobolus*, however, were able to germinate on media covering a still wider range of hydrogen ion concentration. It was conceivable that substances capable of inhibiting the growth of the fungus might be formed in the soil composing the termite workings, but when aqueous extracts of such material were incorporated in the nutrient media no inhibitory effect was to be observed.

These enquiries revealed no reason why the *Conidiobolus* should have failed in field experiments. There are, however, biological factors yet to be taken into account. Thus it has been observed in the laboratory that workers will sometimes "bury" their dead beneath whatever material is available.

If this habit is general in well regulated colonies, then a parasitic fungus might be sealed off in the bodies of insects dead from the disease before conidia formation had occurred to spread the infection. Factors of this nature are clearly much more difficult to assess than the purely physical.

Chemical Control. In the absence of more effective measures, the established methods of control have to be employed. Data relating to costs of treatment and incidence of attack have been compiled, (from records of routine control work on the Experiment Station) for the "crater" method using Cymag and sodium silicofluoride, and for the mercury perchloride method.

The possibility of using some of the recently developed synthetic contact insecticides in place of white arsenic in the "trail injection" method has been examined in the laboratory. This method relies on the poison adhering to the termites' bodies for distribution through the colony, and the experiments were designed to take this factor into account. A worker dusted with the insecticide under study was introduced into a Petri dish containing a number of undusted workers, and the consequent mortality recorded. Judged by this test none of the insecticides was as effective as white arsenic.

IX. Cockchafers

During the years immediately prior to the war, cockchafers assumed a position of importance as pests of rubber and cover crops. Reference to former Annual Reports reveals a steady increase in their prevalence from the year 1929, in which they were first recorded, to 1938, when they appear to have attained their maximum numbers. A slight decline in incidence occurred in 1939, and there is some evidence that this trend was continued during 1940 and 1941. The present position in regard to this pest is reviewed below on the basis of information that has been derived partly from the year's advisory correspondence, and partly from a survey made of all those estates in Kedah which are on record as having suffered from previous cockchafer attacks.

The advisory correspondence involves only seven estates. On one estate, the larvae of *Holotrichia* (= *Lachnosterna*) *bidentata* Burm. were found feeding on the roots of grasses and other natural cover plants in an area of about one fifth of an acre of mature rubber, into which they had migrated

from nearby lalang. There was no indication of damage being done to the rubber roots. From two estates the enquiries were concerned with the possibility of replanting fields that had been extensively damaged by cockchafer in the past. Larvae, mostly species of *Leucopholis*, were found in both places, but in numbers of a far smaller order of magnitude than in the years in which severe damage was sustained. The other estates, four in number, sought advice on the eradication of larvae (predominantly *Leucopholis rorida* F.) from nurseries which had been established in areas cleared from belukar. In all these cases it is noteworthy that the ground was not under rubber cultivation at the time of oviposition by the cockchafer beetles.

Eleven estates were visited in Kedah. Four which had been only lightly attacked in the former years now showed no signs of having incurred any injury. Three others where the attacks had been locally severe were found to have recovered completely. On the four remaining estates which had also suffered heavily in the past the rubber in the affected areas was found to be damaged beyond reclamation, such trees as remained being extremely stunted. Although larvae were still to be found in these places their numbers were smaller than in the years when most of the damage was done. It is not possible now to determine to what extent the damage was caused directly by root destruction and to what extent indirectly through deterioration of soil conditions.

From the evidence available the impression is gained that the decline in incidence of cockchafers which began in 1939 has been continued during the years of occupation and neglect. The inference which must be drawn is that biological factors, unbalanced in the years 1930 to 1938 to the great advantage of the pests, have become readjusted and once more exert a natural control. This does not carry the implication that cockchafers will never more be of economic importance. In the absence of knowledge of the causes behind the considerable changes in their abundance it is impossible to predict future trends.

In connexion with these general considerations it is interesting to compare the relative numbers of the different species involved. The most striking fact which emerges is that *Psilopholis vestita* Sharp, hitherto regarded as the most important species, was not encountered at all during the year 1947; nor was *Lepidiota stigma* F. Most of the larvae were

found to be species of *Leucopholis*, chiefly *L. rorida*. Other Melolonthids, and species of the Rutelid genus *Anomala*, were also met with occasionally. To what extent the apparent decline in importance of cockchafers as pests is due to a decrease in the population of the one species *Psilopholis vestita* is a matter for conjecture.

A Tachinid parasite, as yet unidentified, was bred from larvae of *Holotrichia bidentata*.

Control measures. In reviewing the possible methods of control which might be employed it is desirable to consider mature areas and nurseries separately, because it is only in the latter that the soil receives any cultivation; and without cultivation the use of soil insecticides is unlikely to prove effective. An exception to this can arise in mature areas where the incidence of cockchafer larvae is so high as to result in the soil becoming porous through their activities. It was in situations such as this that injection of carbon disulphide was tried experimentally in the years 1937 to 1939 with considerable success. The cost of the method is high, and there is a certain fire risk which it was shown could be reduced by admixture with carbon tetrachloride without loss of effectiveness. Under present conditions there does not appear to be any scope for the use of these, or any other, soil insecticides in mature rubber.

It is known that it is the habit of cockchafers to re-infest the same area year after year, with only slight modifications to the boundaries of the infested zones. The problem might well arise of ridding a small area of mature rubber of its cockchafer population, which although kept in bounds by natural agencies would, by the continual infliction of root damage, reduce the vigour of the trees. For the reasons given, the most promising approach would seem to be against the pest in the adult stage; either by light-trapping or by the application of contact poisons to soil and foliage.

In nurseries the need to get rid of any cockchafer grubs present in the soil is a pressing one, because of the ease and rapidity with which the pests can destroy the seedlings. Most usually their presence will be detected at the time when the land is being prepared for planting, since nurseries are normally laid down in the latter months of the year when the grubs are nearing full growth and are therefore very conspicuous. In this event their removal by hand is a fairly simple matter involving no great increase in labour. The areas to be treated are, moreover, small. Where this method

for any reasons fails there will be a need for a soil treatment, the cost of which will not be an over-riding factor. Once the nursery is planted further cultivation becomes impossible and the insecticide must be carried into the soil by some other means such as dibbling, soil injection, or irrigation with a finely divided aqueous suspension.

Preliminary tests have been carried out with the soil fumigant D-D (dichloropropane—dichloropropylene). These have shown that rubber seedlings are tolerant of dosages in excess of those normally recommended for the treatment of soil organisms, but no data have yet been obtained of the toxicity of this material to cockchafer larvae. In addition, a small trial was carried out with D.D.T. in a nursery infested with *Leucopholis vorida*. One application of a 0.1% emulsion, at the rate of one gallon per twenty square yards, reduced the number of seedlings destroyed to one third of the control figure. Further work along these lines is dependent on suitable areas becoming available for experimental treatment.

X. Mites

Nursery plants are very commonly found to carry populations of mites and thrips, alone or in association with fungi; moreover, these pests also occur on young leaves of mature trees and are a contributory cause of the secondary leaf-fall which sometimes follows wintering. Most commonly met with, and in the greatest numbers, is *Hemitarsonemus latus* Banks, the Yellow Tea Mite, of which the characteristically marked eggs, with their regular pattern of white dots, are a useful aid in recognition.

Reared on seedlings in the insectary, *H. latus* was found to have a strong preference for the youngest leaves. In the absence of natural enemies the intensity of attack at the tip of the shoot was such as to kill the developing leaves before they expanded. Some plants prevented in this way from putting on any more foliage exhausted their food reserves and died. Others, on which the mite population became greatly reduced when the attacked leaves fell, were able to retain the next whorl of leaves and so survived. These leaves had a characteristic appearance; the whole leaf was paler than normal, puckered, and there were lines of light green spots along the sides of the veins where the epidermal cells had been destroyed by the mites' feeding.

XI. Other Insect Pests

Reports were received of isolated attacks by Gryllids and Coccids on seedlings both in nurseries and in the field. In no case was the damage considerable.

On one estate where *Nephrolepis biserrata* was established as the dominant cover under mature rubber on a steep hillside, the fern became heavily attacked by an unidentified flea beetle. Its interest lay in the possibility that, by repeated defoliation, it would cause the fern to die back over large areas and so expose the soil to erosion.

XII. Nematodes

No case of damage by eelworms was recorded during 1947. This was without doubt because of the much reduced extent of cultivation of leguminous cover plants.

XIII. Other Animal Pests

SLUGS AND SNAILS. An impressive outbreak of slugs was observed on one estate in an area of six-year-old rubber which had been reduced to a low stand during the occupation and was being supplied with stumps. Repeated destruction of the terminal buds of the supplies had produced the characteristic clubbing and multiplication of shoots; in addition, a daily migration of slugs up the trunks in the evening and down to the shelter of heavy ground cover in the morning showed that the young trees were also being attacked. Baits of rice bran containing Meta killed large numbers of the pest, but had the disadvantage that their rapid deterioration necessitated frequent replacement.

Giant snails were responsible for damage to germinating seed in nurseries and planted in the field, but were not found to attack seedlings which had put on their first leaves. Some tests were made with baits which contained lime as the attractant and Meta as the toxic agent consolidated with cement. Although very resistant to weathering, these baits lacked the attractiveness of bran baits.

RATS. Where cases of rat damage occurred in replantings, the areas were under dense natural covers which provided excellent harbourage. Attention to general field sanitation and the use of poisons brought the pests under control. In two instances it appeared that the rats had been attracted to the area by a manure which incorporated prawn dust.

XV. Root Nodule Bacteria

Six strains of *Rhizobium* isolated from the root nodules of *Centrosema pubescens* were tested on plants grown in sterile, washed sand with a nitrogen-free nutrient solution. Only two were found to be effective. Inoculation with these had the result (after nine weeks' growth) of doubling the dry weights of the plants and increasing their total nitrogen content four times. Analysis of the plants was carried out by the Soils Division.

There has been no demand for cultures of *Rhizobium* during the year. It seems probable that estates have been deterred from growing leguminous covers because of the scarcity and high price of the seed.

Miscellaneous

IDENTITY OF THE FUNGUS PARASITIC ON *Coptotermes curvignathus*. Reference to the literature had indicated that this fungus (see p.127 above) was closely related to *Conidiobolus villosus* Martin, a species (originally described as a saprophyte from Iowa) which had been reported as being parasitic on termites in Cuba (Kervokian, A.G., *J. Agric. Univ. Puerto Rico*. 1937, 20, 191-199). However since the Malayan fungus was not observed to form the villose resting spores which are characteristic of *C. villosus* it was tentatively regarded as a new species. In June, two subcultures of *C. villosus* (one derived from Martin's type culture) were received from the Commonwealth Mycological Institute, and a comparative study of these and of two isolations of the local termite parasite was begun. To start with it was not found possible to induce any of the cultures to form villose resting spores, but subsequently, when a number of other media had been tried, all were observed to produce these structures on Difco malt agar after about three weeks growth; though the tendency to do so was far less marked in the Malayan isolations than in the other two.

The pathogenicity of the four cultures was compared, and they were found to exhibit no significant difference in their capacity to parasitize and kill the workers of *Coptotermes curvignathus* under the conditions previously described. Indeed the only marked difference of any sort noticed between the local isolations and the two received from England has been in their macroscopic appearance on agar slants; and this appears to arise merely from the fact that the former tend to shoot more conidia on to the walls of the culture tubes

than do the other two. On the strength of these observations, it would seem justifiable to regard the Malayan fungus as no more than a strain of *Conidiobolus villosus* Martin.

Advisory Work

The appendix to the Director's report will show that 522 letters were despatched from the Division during the year. About 140 specimens were sent in for examination, half of which were representative of cases of secondary leaf-fall. The graduate staff of the Division paid 71 visits to estates and smallholdings and 40 visits to the Experiment Station. Interviews at the Institute totalled 97.

The leaflet dealing with the control of root disease in young rubber was revised and issued as P/AL. 1(47).

Publications

"Notes on the Treatment of Fire-damage"

The Planter 1947, 23(7), 167.

"Risks Arising from the Use of Sodium Arsenite"

(In collaboration with the Soils Division)

The Planter 1947, 23(10), 253.

"A Fungus Parasitic on *Coptotermes curvignathus*, Holmgr."

R.A. Altson, *Nature* 1947, 160(4056), 120.

R. A. ALTSON

Head of Pathological Division

KUALA LUMPUR.

16th December, 1948.

REPORT FOR THE YEAR 1948

STAFF AND GENERAL

The Head of the Division (Mr. R. A. Altson), the Entomologist (Dr. A. Newsam), and the Assistant Pathologist (Mr. K. P. John) were on duty throughout the year.

Mr. F. W. Hutchison arrived in Kuala Lumpur and assumed duty as Advisory Officer on the 4th March, 1948. Mr. Hutchison was seconded to the Experiment Station, Sungei Buloh, on the 8th March and returned to Headquarters on the 24th June.

Mr. R. N. Hilton arrived in Kuala Lumpur on the 6th September, 1948, and assumed duty as Pathologist on the following day.

Mr. Hoh Choo Chuan resumed duty as Artist and Photographer on his return from home leave on the 29th February, 1948. Mr. Chan Tham Yew, Assistant Artist and Photographer, ceased to act in the senior appointment from that date.

Acknowledgement is made to the Director, Commonwealth Mycological Institute, for much valuable advice received during the course of the year; to the Director, Department of Agriculture, Federation of Malaya, for facilities extended to the Entomologist; and to those managers of estates in Selangor who have co-operated with us in some of our field experiments.

I. Diseases of the Root System

General Observations. As an outcome of the interest that is now being taken in the possibilities of clearing stands of old rubber by completely mechanised means, we have frequently been asked to give an opinion on the effect this method of clearing is likely to have on the subsequent incidence of root disease in the replanting. The full answer to this question depends, of course, on the degree of efficiency with which the roots of the old stand are removed; but, although we have as yet no direct experimental evidence to go on, the data derived from some of our former replanting experiments enable us to state with some confidence that, even given the same disease incidence, the cost of root disease control in a replanting established on land that has been cleared by a combination of stumping and rooting will be markedly less than that in one established on land cleared by poisoning.

An analysis of the monthly reports received from the Smallholders' Advisory Service has shown that root disease was evident in about 5 per cent. of the 46,000 smallholdings visited during the year. A number of these outbreaks occurred in young replanted rubber.

(1) STUDIES CONCERNED WITH THE GROWTH, PATHOGENICITY AND DISPERSAL OF THE THREE MAJOR ROOT PARASITES

The manner in which potential sources of infection become converted into actual ones. The main, if not sole way in which a replanting of rubber becomes affected by root disease is through spread of the disease (by the way of root contacts) from infected stumps, or root fragments, left behind by the previous stand.

Considered in relation to the part they may play as future sources of infection for the new stand, the old trees in an area destined for replanting fall into two distinct categories, namely: those whose stumps will become *actual* (i.e. active) sources of infection; and those whose stumps will become *potential* sources of infection. The first category comprises the trees whose roots are already diseased at the time of clearing; and in a field of old rubber such trees will occur, almost without exception, on the margins of open patches which have developed as the result of the gradual destruction of a part of the stand by spread of the disease from some central focus.

The second category is represented by the trees, growing well away from the open patches, which appear perfectly healthy at the time of clearing. The stumps of these trees are said to form *potential* sources of infection because experience has shown that despite their original freedom from disease they frequently become invaded by *Fomes lignosus* or, less frequently, by *Fomes noxius*, and thus converted into *actual* sources of infection.

Most of the old rubber which is earmarked for replanting was originally established on land cleared from forest, and the parasites now growing in the roots of the trees whose stumps will become the *actual* sources of infection have reached their present situation by slow centrifugal spread from some jungle stump that was either diseased at the time the forest was felled or which became diseased shortly afterwards. But how these parasites succeed in invading the stump of a tree that has remained apparently unaffected by root disease for 30 or more years, thus converting it from a *potential* into an *actual* source of infection, is still not understood.

Two explanations of this phenomenon have been advanced: one that the cut surface of the healthy stump becomes infected through the agency of air- or insect-borne spores; and the other that the fungus is present in the roots (or in the soil in contact with the roots) in a dormant condition and springs into activity when the resistance of the host tissue is lowered by severance of the stem. The first of these two hypotheses (which is the more orthodox one) held the field in the early days of the rubber industry, when attention was drawn to the phenomenon not, of course, by its occurrence in replantings, but by the spread of infection from the stumps of apparently healthy trees which had been felled in the course of thinning-out a stand. But largely owing to the growth of an erroneous belief that the fructifications of *Fomes lignosus* were invariably sterile, this older theory was eventually discarded, and the

hypothesis of dormant sources of infection emerged. And although Napper* subsequently showed that *Fomes lignosus* actually produces spores in abundance during certain seasons of the year, the latter hypothesis continued to gain ground not only in Malaya, but also in Ceylon and Indonesia; receiving considerable support in 1939 from the publication of what appeared to be confirmatory observations on *Armillaria mellea* in Africa†. As late as 1940, Napper‡ expressed his views on this phenomenon in the following words: "The origin of this "attack is at present obscure. The sources have so far proved "undetectable, and it is not yet possible to say with certainty "whether they are generally present in mature areas (in the "soil or in the roots of the old trees), or are introduced after "felling through the agency of wind-blown spores (though this "latter mode of introduction is regarded as unlikely)."

As, however, no convincing evidence has ever been adduced to justify acceptance of the theory of dormant sources of infection, in so far as rubber and its major root parasites are concerned, an investigation was begun towards end of 1947 which it was hoped might throw some light on the matter. Since the basis of the theory is that a dormant parasite lying within, or in close contact with the host is stimulated into activity by a decline in resistance of the host tissue, the procedure adopted was as follows: large lateral roots of 20-year old trees were exposed, severed by a saw cut, and then re-covered with soil. Once a month, for a period of twelve months, a proportion of the severed roots was removed and brought back to the laboratory for detailed examination.

The results were entirely negative. Indeed the only pathogen of rubber whose growth appears to have been encouraged by the experimental treatment was *Ustilina zonata*—a well-known wound parasite. This single experiment cannot, of course, be held to disprove the theory of dormant sources of infection—it has merely failed to confirm it; but it is nevertheless of some significance that the field (No. 9 at Sungei Buloh) where the observations were made was one in which the incidence of *Fomes lignosus* had been particularly high during the first four or five years after planting.

Further information having an important bearing on this question has emerged from another observation made at Sungei Buloh. A round of collar inspection carried out in February in Field 32 (planted in 1937; budded in 1939) brought to light the fact that the number of cases of disease due to *Fomes noxius* had increased by nearly 30 times in the nine

* Napper, R. P. N., *J. Rubb. Res. Inst. Malaya* 1932, 4, 5-33.

† Leach, R., *Trans. Brit. Mycol. Soc.*, 1939, 23, 320-329.

‡ Napper, R. P. N., R.R.I.M. Pathological Division Advisory Leaflet No. 3, 1940.

months that had elapsed since the previous inspection. The source of this outbreak was found to be the stumps of the trees that had been felled during the course of thinning two years earlier. These had been cut at about 18 inches above ground level, and their butts then stripped of bark to prevent the shooting of dormant buds. A careful examination of a number of these stumps made it quite clear that their infection had not been brought about by root contacts but had been initiated at some point on the stem, the obvious inference being, therefore, that it had occurred through the agency of air- or insect-borne spores. Furthermore, there was a suggestion that this spore infection had actually been favoured by the removal of the bark, for in another field (35B) which was thinned-out at the same as Field 32, but where the butts were not stripped, the incidence of *Fomes noxius* has remained normal. However, it would be unwise to regard this as any more than a suggestion because the difference between the two fields might well have been the result of a difference between the relative prevalence of the primary sources of the infection, namely, fructifications of *F. noxius*.

Influence of the age and vitality of the host on the activities of the three major root parasites. As a contribution towards a solution of the problem discussed above it seemed that an attempt should be made to obtain information on the influence of the age and vitality of the rubber root on the activities of the three major parasites. Accordingly the following experiment has been laid down at Sungei Buloh. Using portions of naturally infected roots as inocula, two laterals from each tree of a group of 16 twenty-year-old trees and two laterals from each tree of a group of 16 six-year-old trees have been inoculated with one of the three root parasites; there being therefore a total of 96 trees (six groups of 16 trees each) involved. In each case one of the two laterals has been severed with a saw cut. Thus the influence of the state of the host on each of the three parasites is being studied under four sets of conditions each represented by a total of 16 roots; these four sets of conditions being as follows:—

- (i) Trees 20 years old; roots intact
- (ii) Trees 20 years old; roots severed
- (iii) Trees 6 years old; roots intact
- (iv) Trees 6 years old; roots severed

Four roots representative of each of the above sets of conditions for each parasite are being removed and brought to the laboratory for examination at two-monthly intervals. By the end of the year only the first series of observations (those made two months after inoculation) had been completed. The results are tabulated below.

TABLE VIII. *Influence of the age of the trees on the activities of the root disease parasites*

Condition of intact roots two months after inoculation

Age of the trees	F. lignosus		G. pseudoferreum		F. noxius	
	6 yrs.	20 yrs.	6 yrs.	20 yrs.	6 yrs.	20 yrs.
No. of roots inoculated	4	4	4	4	4	4
No. of roots infected	4	4	nil	1	1	nil
Mean length of epiphytic growth ..	24"	22"	nil	5"	2"	nil
Max. length of epiphytic growth ..	43"	30"	nil	5"	2"	nil
No. of roots penetrated ..	1	2	nil	nil	1	nil
Mean length of penetration * ..	3"	2"	nil	nil	0.25"	nil

* By "penetration" is meant invasion of the cortex or wood accompanied by obvious necrosis.

TABLE IX. *Influence of the vitality of the roots on the activities of the root disease parasites*

Condition of the roots two months after inoculation

(a) Trees 6 years old

State of roots	F. lignosus		G. pseudoferreum		F. noxius	
	Intact	Severed	Intact	Severed	Intact	Severed
No. of roots inoculated	4	4	4	4	4	4
No. of roots infected	4	4	nil	nil	1	1
Mean length of epiphytic growth ..	24"	20"	nil	nil	2"	2.5"
Max. length of epiphytic growth ..	43"	32"	nil	nil	2"	2.5"
No. of roots penetrated ..	1	3	nil	nil	1	1
Mean length of penetration ..	3"	2"	nil	nil	0.25"	0.25"

(b) *Trees 20 years old*

State of roots	F. lignosus		G. pseudoferreum		F. noxius	
	Intact	Severed	Intact	Severed	Intact	Severed
No. of roots inoculated	4	4	4	4	4	4
No. of roots infected	4	4	1	2	nil	2
Mean length of epiphytic growth ..	22"	29"	5"	6"	nil	9"
Max. length of epiphytic growth ..	30"	33"	5"	9"	nil	12"
No. of roots penetrated ..	2	3	nil	nil	nil	2
Mean length of penetration ..	2"	3"	nil	nil	nil	9"

While it would be unwise to attempt to draw any far-reaching conclusions from the single series of observations summarized in the tables above, it is permissible to call attention to the evidence indicating that *Fomes lignosus* greatly surpasses both *Ganoderma pseudoferreum* and *Fomes noxius* in virulence and vigour. Another point worthy of notice is that *F. lignosus* not only succeeded in infecting all four of the intact 20-year-old roots within two months of inoculation, but in penetrating two of them in addition; a result that seems to throw some doubt on a theory that postulates the existence of dormant sources of infection.

It was established that the failure of *G. pseudoferreum* to infect any of the roots of the six-year-old trees and *F. noxius* to infect the intact roots of the 20-year-old trees was not due to a loss of viability, since in each case it was found possible to isolate the parasite from the root fragment that had been used as an inoculum.

Factors affecting the pathogenicity of Fomes lignosus. An attempt is being made to throw some light on the factors affecting the pathogenicity of *Fomes lignosus* by observations based on infection experiments with young potted seedlings. In the first experiment to be completed, seedlings raised under sterile conditions on sand were liberally inoculated with a pure culture of the fungus soon after germination. No infection

resulted. Observations are now in progress on the effect of using fragments of naturally infected roots as inocula.

(2) **STUDIES CONCERNED WITH THE IMMEDIATE PROBLEM OF ROOT DISEASE CONTROL**

Field study of the economics of root disease control. A large-scale field experiment designed to study the economics of root disease control in a replanting is being laid down on two sites; one on an inland granitic soil (Pataling Estate) and the other on a coastal clay (Dusun Durian Estate).

The object of this experiment is (a) to compare the efficacy and cost of two methods of root disease control in young rubber, and (b) to assess the relative economic values of these methods of control by means of subsequent records of yield.

The two methods of control that are to be employed will differ only in respect of the procedure that will be used to detect the presence of the disease; the subsequent treatment being the same in both cases, namely: removal and burning of diseased roots and of the original source of infection. The presence of the disease will be detected in one case by means of periodic tree-to-tree collar inspections, and in the other by the appearance of characteristic symptoms in the foliage.

With the first method (which is the one that we recommend at present) it is possible to detect infection not only early enough to prevent further spread of the disease, but also early enough to permit the successful application of curative measures. With the second (which is the older method and one that is still practised on many properties), by the time the effects of the disease have become apparent in the foliage the tree is beyond treatment and must be removed. While, at first sight at any rate, there would seem to be little question that the method based on periodic inspection is the more efficacious of the two, this point has never actually received experimental proof. And what is perhaps more important, it has yet to be shown that the additional cost of this method can be justified by the fact that fields so treated will give better returns than those treated by the older and cheaper method.

"No treatment" plots have been included in order to make the experiment complete. Apart from the fact that the presence of such plots are necessary for a proper evaluation of the other two treatments, they will serve the further purpose of putting to test the theory that has gained currency since the war, namely: that the disturbance of the soil which

inevitably accompanies root disease treatment actually tends to increase the rate of spread of the parasite. In these "no treatment" plots, therefore, dead or dying trees will be removed (with the minimum of soil disturbance) only when they are causing an obstruction.

The three treatments to be studied in this experiment may be summed up as follows:—

A. Eradication based on detection of the disease by periodic tree-to-tree inspection.

B. Eradication based on detection of the disease by the appearance of characteristic symptoms in the foliage.

C. No eradication. Dead or dying trees to be removed only when necessary, and then with the minimum of soil disturbance.

Each treatment will be replicated six times in two-acre plots, making a total experimental area of 36 acres. The layout will take the form of two 3 x 3 Latin Squares. To prevent interference between neighbouring plots, each is to be surrounded by a properly maintained isolation trench.

It is proposed to carry out two rounds of inspection and treatment annually until the trees are five years old, the first round being made when they have reached an age of about 18 months. From the sixth year onwards, only one round will be carried out each year. Tree-to-tree inspection in the A plots will cease as soon as there is evidence that the disease has been virtually eradicated, which, to judge from previous experiments, should be somewhere about the seventh or eighth year.

In addition to records of disease incidence, careful records of the cost of all three treatments will be kept; and by relating these figures to the subsequent records of yield and of production costs, which it is proposed should be maintained over a period of years, it should eventually be possible to decide once and for all which of these forms of root disease treatment is in reality the most economical.

By the end of the year under review the final demarcation of the experimental plots on Dusun Durian Estate had been completed, but conclusion of the work on Pataling Estate was held up by circumstances beyond our control.

Evaluation of various methods of stump-poisoning. What information we have regarding the value of stump-poisoning as a method of root disease control in a replanting is derived from two field experiments laid down by Napper—one on Batang

Kali Estate in 1937 and the other on Highlands Estate in 1938. The same method of poisoning was employed in both experiments; the poison (50 per cent. sodium arsenite) being introduced into a low-cut stump through one-inch-auger holes bored into its cut surface (i.e. the method described in this Division's advisory leaflet No. 4 of 1940).

In the Batang Kali experiment, the merits of stump-poisoning as a method of root disease control were judged in comparison with several forms of clean-clearing. The Highlands experiment on the other hand was designed so as to give a clearer picture of its value, since in this case it was compared with a control in which the stumps were left untreated. The conclusions that were drawn from these two experiments are well known: they are, briefly, that stump-poisoning with sodium arsenite could not be relied upon to neutralize active sources of infection, but might (with certain provisos) be usefully employed for the control of potential sources of infection.

As it happens, the method of poisoning that had been adopted in both these experiments was open to the not unimportant objection that it was applicable only to low-cut stumps, that is to say stumps from which the stem had been severed just above ground level; and to fell trees at this height is more difficult, and therefore more expensive, than at the more usual height of about $2\frac{1}{2}$ feet. Well aware of this objection, and realising that to poison a high-cut stump effectively might need a modification of technique, Napper, in 1941, laid down an experiment on Emerald Estate specifically designed to investigate this point; but this unfortunately was one of the experiments that we had to abandon in 1946 owing to our inability to locate the plots.

As the same objection to the only method of stump-poisoning that has ever been tested still holds good today, it has been evident for some time that steps should be taken to investigate other methods; and not only modifications applicable to high-cut stumps, but methods which dispense with the use of an auger altogether; for in these days even the boring of auger holes has become a costly operation.

The obvious way in which to evaluate different methods of stump-poisoning is by means of a root disease experiment*; but as this could not be expected to yield any worth-while results in less than five years it was decided that an attempt should be made to approach the problem in another way. The practice of stump-poisoning derives from the hypothesis that parasites

* by this is meant an experiment designed to determine the effect of the different methods on the incidence of root disease.

such as *Fomes lignosus* cannot become established in tissue that has already been invaded by the common saprophytes. If this is true, it follows that a root may be rendered impervious to the parasite merely by killing it, and thus laying it open to invasion by the saprophytes. On this basis an effective method of stump-poisoning may be assumed to be one that results in the poison penetrating the roots rapidly; in large quantities; and to a considerable distance. An experiment was therefore laid down on Pataling Estate (in the area that was being felled for replanting) which was designed to provide data that would enable us to judge with what degree of success various methods of stump-poisoning met these requirements.

Five treatments (consisting of four methods of stump-poisoning and an untreated control) were compared, each treatment being replicated five times. The treatments were as follows:—

A. The poison introduced through one-inch-auger holes bored from the outside of a high-cut stump inwards and downwards over the lateral roots.

B. The poison introduced through one-inch-auger holes bored from the cut surface of a low-cut stump downwards and radially outwards towards the laterals. (The method used in the Batang Kali and Highlands Estates experiments).

C. The poison mixed with a paste made from tapioca flour and painted on to the cut surface of the stump. (A method that has found favour on several estates).

D. The poison poured directly into the fissures left on the cut surface of the stump. (The method used on Pataling Estate).

E. Control. No treatment.

Each treated stump received 15 ounces of sodium arsenite applied as a 50 per cent. solution.

At intervals of 24 hours, 3 days, 6 days and 12 days after poisoning samples were removed from the laterals (by means of a half-inch auger) at distances of 1 foot, 3 feet and 6 feet from the bole, a different lateral being sampled on each occasion. Each set of five identical replicates (*i.e.* identical for time, distance, and method of treatment) was bulked* and handed to the Soils Division for determination of arsenic content. The results of these analyses are tabulated below.

* This bulking was considered necessary at the time in order to reduce the number of individual analyses to reasonable proportions (*i.e.* from 300 to 60).

TABLE X. *Evaluation of various methods of stump-poisoning*
Arsenic content of lateral roots

P.p.m. As₂O₃ in oven dry samples
(mean of duplicates)

Method	Distance from bole	Time of sampling			
		24 hrs.	3 days	6 days	12 days
A ..	1 ft. ..	1,176	510	1,322	1,028
	3 ft. ..	25	11	99	105
	6 ft. ..	39	13	238	45
B ..	1 ft. ..	6	165	39	402
	3 ft. ..	4	24	29	21
	6 ft. ..	2	12	14	19
C ..	1 ft. ..	5	6	5	29
	3 ft. ..	2	9	34	5
	6 ft. ..	4	7	6	4
D ..	1 ft. ..	7	72	95	20
	3 ft. ..	6	12	89	10
	6 ft. ..	3	9	117	12
E ...	1 ft. ..	4	6	4	5
	3 ft. ..	3	6	5	5
	6 ft. ..	6	6	6	6

Despite a certain inconsistency about the above figures it seems permissible to infer from them that method A provides the most effective means of introducing the poison into the laterals; that there is little to choose between methods B and D (except on the score of costs, which would be very much in favour of D); and that method C is virtually useless. An examination of the stumps carried out six weeks after the application of the poison has, however, thrown some doubts on the efficacy of method A. This disclosed that only those laterals in the immediate vicinity of the auger holes were affected by the treatment, the remainder still being healthy. With method B, on the other hand, there appeared to have been a more uniform distribution of the poison. In D, it seemed as if the effect of the treatment had been confined to the surface roots; although there was some indication that a

decay of the taproot had set in. The condition of the roots in method C was indistinguishable from that of the controls.

This experiment is regarded as having been merely exploratory, and it will be repeated, with certain modifications of technique, as soon as another convenient site for it can be found.

Tolerance to arsenic of the three major root parasites. As it is conceivable that the introduction of sodium arsenite into a stump prevents it becoming invaded by a parasite not for the usually accepted reason alone, but also because the tissues are actually made toxic to the organism, it was thought that it would be of interest to obtain some information on the tolerance to arsenic of the three major root parasites. A preliminary study of the question has been made, and this has produced evidence of a difference in sensitivity between the three species. On potato-dextrose agar containing 0.0625 per cent. As_2O_3 the growth of *Fomes lignosus* differed but little from the controls; that of *Ganoderma pseudoferreum* was somewhat retarded; and that of *Fomes noxius* was completely inhibited.

The concentration of As_2O_3 that was tolerated by *F. lignosus* in this study is (as reference to Table X will show) in excess of the concentration established in the roots by any of the experimental stump-poisoning treatments, with the possible exception of that found at one foot from the bole in method A. And if the moisture content of fresh roots is taken as 50 per cent., even the highest of these concentrations (1,322 p.p.m.) is still only of the same order of magnitude as that which was present in the culture medium.

Use of D-D for the control of active sources of infection. In 1947, the idea arose that it might be feasible to neutralize active sources of infection, before replanting, by injecting D-D (dichloropropane-dichloropropylene) into the soil in the neighbourhood of the infected trees which are usually to be found bordering root disease patches; and the report for that year contains an account of some preliminary observations made in connexion with this proposal.

Subsequent examination of the cost of such an operation has shown it would so far exceed the cost of eradication by digging that how ever effective the D-D might be its use would be quite uneconomic. The conclusion has therefore been reached that large scale field experiments with this substance cannot be justified. We have, furthermore, reason to believe that the injection of large areas of soil can be carried out

economically only by mechanically operated equipment (which could not be used on rubber land until it had been completely clean-cleared), and that the lack of tilth characteristic of rubber soils would effectively prevent any lateral or downward diffusion of the D-D vapour.

Antagonism of Trichoderma viride to Fomes lignosus. During the course of the preliminary observations on D-D made in 1947, an effect was observed which suggested that *Trichoderma viride* (a common soil organism) might be antagonistic to *Fomes lignosus*. As this was clearly a matter of more than passing interest it has been made the subject of further study; and evidence that the *Trichoderma* can in fact inhibit the growth of *F. lignosus* when both organisms are grown on the same agar plate has been obtained. This effect, however, has only been observed on one kind of agar medium, namely a medium made from a decoction of Hevea root cortex, which itself was prepared by boiling 1-lb. of fresh bark in a litre of distilled water for half an hour.

No significant retardation of the growth of *F. lignosus* followed use in the agar medium of the filtrate derived from cultures of *T. viride* on the bark decoction, but it is conceivable that the subsequent autoclaving of these filtrates tended to destroy any antibiotic substance that might have been present.

II. Diseases of the Tapping Panel

(1) MOULDY ROT (*Ceratostomella fimbriata*)

General Observations. Mouldy rot has continued to give trouble all over the country. On a few properties the disease has got so out of hand that almost 50 per cent. of the acreage is now infected. Attention was called in the previous report to some of the factors which are contributing to the difficulty of bringing this disease under control. A certain reluctance to discard methods of treatment that may perhaps have been adequate in the days when labour was both cheap and plentiful does nothing to help matters. Frequent (and efficient) fungicidal application is the *sine qua non* for the eradication of mouldy rot from trees that are being kept in tapping; and, without employing a far larger force of labour than it is usual to allot to such a task, this condition cannot be met by podians furnished merely with paint brushes or, even worse, pieces of coconut husk. Towards the end of the year there were, however, signs that our advocacy of the use of sprayers for this work was beginning to receive notice.

Judging by the results of our field trials of the approved fungicides (which are recorded elsewhere in this report) there seems to be a measure of justification for the complaints we have received of the ineffectiveness of some of these preparations. When considering these figures it should nevertheless be borne in mind that all the fungicides were compared at the same concentration, namely 5 per cent. in water, which in the case of two of them is lower than the recommended minimum.

In November, the Smallholders' Advisory Service reported that a most unexpected outbreak of mouldy rot had occurred on many smallholdings in North Kedah and Perlis, a district which until then had been considered to be entirely free from this disease. The explanation of this outbreak—that the disease had been introduced by labourers from Central Kedah, who had come north in large numbers for the padi harvest—seems extremely plausible. The monthly reports of this same Service show that mouldy rot was prevalent on smallholdings in the Sungei Patani district throughout the year; and there is little question that the spores of *Ceratostomella fimbriata* can be transported over long distances not only on tapping knives, but on the clothing of tappers.

Comparison of spraying and painting as methods of application. A series of trials has been carried out on the Experiment Station with the object of securing reliable data as to the relative cost and efficacy of spraying and painting as methods of applying fungicides to tapping panels. The results are summarized below:

Table XI. *Comparison of Spraying and Painting*

Experimental Conditions

Stand: 85 trees per acre.

Mean length of tapping cut: 20 inches.

Wages: \$1.50 per day.

Cost of Fungicide: \$16/- per 5 gallons.

Type of Sprayer: No. 5 Vermorel Pneumatic Hand Sprayer.

Type of Brush: 2 in. Paint Brush.

Results

(a) Based on 5-hour Working Day

	Acres per man-day	Fungicide per man-day	Cost per acre (cents)		
			Labour	Fungicide	Total
Spraying ..	15.5	3.6 gal.	9.7	3.7	13.4
Painting ..	11.5	0.9 gal.	13.0	1.3	14.3

(b) Based on 6-hour Working Day

	Acres per man-day	Fungicide per man-day	Cost per acre (cents)		
			Labour	Fungicide	Total
Spraying ..	18.6	4.3 gal.	8.0	3.7	11.7
Painting ..	13.8	1.1 gal.	10.9	1.3	12.2

It will be seen from these figures that the use of a sprayer results not only in a significant saving of labour costs but in a marked increase in the acreage covered in a working day. The latter is a most important effect, for it enables the interval between treatments to be reduced without any additional call on labour. At first sight it would appear that the saving on labour costs is largely offset by an increase in the cost of the fungicide, but this is only because the figures fail to take into account the significance of this increase. When a sprayer is used it is possible to distribute the fungicide in a 5 to 6 inch band extending well above and below the cut, thus greatly improving the efficacy of the treatment. The increase in expenditure on fungicide which is necessary to secure this improvement is therefore more than justified. To attempt to obtain the same result with a brush would cost just as much in fungicide and far more in labour.

Development of an improved type of sprayer. There appears to be no sprayer manufactured which can be considered entirely suited to the work of spraying tapping panels. The type represented by the Vermorel Pneumatic Hand Sprayer is the best that is available. But this suffers from the serious disadvantage that its working capacity is only $3\frac{1}{2}$ pints, which results in an appreciable part of the working day being lost through the time occupied in re-filling. As the outcome of a number of trials with different types of spraying equipment, we have come to the conclusion that the most suitable machine for the purpose would be a pneumatic knapsack sprayer with a capacity of $1\frac{1}{2}$ to 2 gallons working at a pressure of about 60 lb. per square inch, and fitted with a short lance equipped (a) with a trigger control, and (b) with a nozzle that delivers the spray at the rate of about 250 cc. per minute in a cone that is about 6 inches in diameter at a distance of a foot from the nozzle. An experimental machine complying broadly with this specification, which was built up from parts derived

from three proprietary sprayers, has been tried out at Sungei Buloh with satisfactory results. It now remains to be seen whether we can interest anyone in its manufacture.

(2) BLACK STRIPE (*Phytophthora palmivora*)

General observations. A serious outbreak of black stripe that occurred on an estate in Kedah provided an example of a phenomenon more familiar in Ceylon than in this country, namely, the enhanced susceptibility to *Phytophthora* bark rots of newly opened panels compared with those that have been in tapping for some time. In this instance two widely separated areas both carrying 9-years trees of clones Pil. B.84 and Tj.1 developed symptoms of the disease within three weeks of being brought into tapping for the first time. Neighbouring stands, including at least one block of 10-year old Tj.1, which had been in tapping for twelve months or longer were unaffected. No reasonable explanation of this curious effect has ever been advanced. The source of the infection in this particular case was not determined.

Only two other cases of black stripe came to notice during the year. One of these occurred in the Sungei Siput district of Perak and one in the Rompin district of Negri Sembilan.

Observations on the pathogen. *Phytophthora palmivora* has been isolated from a case of black stripe occurring on an estate in Perak. The culture, which was at first heavily contaminated with bacteria, was purified by passage through living bark. Inoculation experiments have shown this isolation to be capable of causing a die-back of young shoots.

(3) EVALUATION OF FUNGICIDES

Preliminary phytocidal and fungicidal tests. Fourteen proprietary fungicides were subjected to phytocidal (bark-burning) tests and *in vitro* fungicidal tests preparatory to their trial in the field against mouldy rot. In the phytocidal tests each fungicide was tried out at three concentrations, each concentration being applied with a brush to the newly tapped bark of four budded trees on six (alternate-daily) tapping days, one tapping day being allowed to elapse between the first and second applications.

The *in vitro* tests were made in the manner described in the previous annual report. The results of these tests are summarized in Table XII below. In this table, by *Phytotoxic limit* is meant the concentration at which slight signs of injury to the cortex first become apparent; and by *Fungicidal limit*

the minimum concentration at which the growth of the pathogen is completely inhibited.

TABLE XII. *Results of preliminary phytocidal and fungicidal tests*

Fungicide	Phytotoxic limit	Fungicidal limit
Rotdoom C (sodium pentachlorophenate) ..	0.25% ..	0.06% ..
Phenyl Mercury Fixtan (phenyl mercuric hydroxide + formaldehyde) ..	1.0% ..	1.0% ..
Phygon (dichloro-naphthoquinone) ..	1.0% ..	0.5% ..
Fermate (ferric dimethyl-dithiocarbamate) ..	Not reached at 1.0% ..	1.0% ..
Zerlate (zinc dimethyl-dithiocarbamate) ..	Not reached at 1.0% ..	Not reached at 1.0% ..
Dithane Z-78 (zinc ethylene-bisdithiocarbamate) ..	Not reached at 1.0% ..	Not reached at 1.0% ..
Shirlan (salicylanilide) ..	Not reached at 1.0% ..	Not reached at 1.0% ..
T.M.T.D. (tetramethyl-diuramdisulphide) ..	Not reached at 1.0% ..	0.5% ..
Sodium DNOC (sodium dinitro-orthocresylate) ..	0.25% ..	Not reached at 0.25% ..
Lissolamine A (cetyl trimethyl-ammonium bromide) ..	1.0% ..	0.25% ..
Fixanol V.R. (tetradecyl pyridinium bromide) ..	0.5% ..	0.125% ..
Octyl Cresol in palm oil ..	Not reached at 5.0% ..	Not tested as not water miscible ..
Octyl Cresol Emulsion ..	Not reached at 10.0% ..	Not reached at 10.0% ..
White Kerol (tar acid emulsion) ..	Not reached at 5.0% ..	5.0% ..

On the strength of the results recorded above the following fungicides were discarded as being either ineffective at economic concentrations or toxic at or below the fungicidal limit. Phenyl Mercury Fixtan, Zerlate, Dithane Z-78, Shirlan, Sodium DNOC, Octyl Cresol Emulsion. Arrangements were made to subject the remainder to field trials during the wet weather normally to be expected during last three months of

the year. However, owing to a complete failure of the rains in December part of the programme had to be postponed, with the result that two of the preparations were still awaiting test at the close of the year.

Field trial of synthetic fungicides. The following synthetic fungicides were tested against mouldy rot in an experiment laid down on an estate in Selangor:—Fixanol V.R., Lissolamine A., T.M.T.D., Fermate and Rotdoom C.

The test plots, consisting of 25 trees each, were treated every tapping day (*i.e.*, alternate-daily) for a total of 14 days, the fungicides being applied by means of a pneumatic hand sprayer. An untreated control, and a plot treated with an approved fungicide were set up for comparison. Fixanol V.R. at 0.25% has shown considerable promise. At this concentration it succeeded in eradicating the disease completely after eight applications, whereas twelve applications with the approved fungicide were required to produce the same result. The full results of this trial are summarized in Table XIII below.

Before directing attention to this table the following explanation is necessary of the manner in which the figure denoting the *efficacy* of a compound has been arrived at. With the object of providing a more accurate picture of the behaviour of a fungicide under test, in all field trials conducted since 1947 the state of the disease on each tree in each of the experimental plots has been recorded (on the day following treatment) under one of four heads, namely:—

Mouldy = mould extending along not less than half the length of the tapping cut.

Some mould = mould present on less than half the length of the tapping cut.

Trace = mould present only as one or two small isolated colonies.

No trace = the panel free from all traces of mould.

By allotting a numerical value to each of these four categories it is possible to arrive at a figure which, since it takes into account the two intermediate stages in the progress of a treatment, provides a fairer basis for comparison than the bare citation of the number of cases cured.

The values that have been chosen for this purpose are:—
Mouldy = 0. Some mould = 1. Trace = 2. No trace = 4.

As there are 25 trees to each test plot, a score of 100 on this scale signifies that the disease has been completely eradicated from the plot.

TABLE XIII. *Trial of synthetic fungicides*
Assessment of efficacy after 14 applications

Fungicide	Concentrations	Efficacy (100 = complete control)
Fixanol V.R. ..	0.25 % 0.125%	100 (a) 86
Lissolamine A ..	0.5 % 0.25 %	91 53
T.M.T.D. ..	1.0 % 0.5 %	70 43
Fermate ..	1.0 %	52
Rotdoom C ..	0.1 % 0.05 %	40 30
Approved fungicide A*	5.0 %	100 (b)
Control ..	—	0

(a) Reached after 8 applications. (b) Reached after 12 applications.

Further tests at higher concentrations with Lissolamine A, whose performance at 0.5% was at least as good as that of any approved fungicide other than A*, appears to be precluded by considerations of price. The same applies to T.M.T.D. and Fermate. In the case of Rotdoom C, any significant increase in strength would bring the solutions too near the phytotoxic limit to be safe.

Field trial of approved fungicides. A comparative trial of all the approved water-miscible tar acid fungicides has been carried out. The experimental conditions were the same as those described above. A similar trial was conducted in 1947. The results obtained in both years are summarized below.

* See Table XIV.

TABLE XIV. *Comparison of approved fungicides**Assessment of efficacy at a concentration of 5 per cent.*

Fungicide	Efficacy (100 = complete control)			
	After 7 applications		After 14 applications	
	1947	1948	1947	1948
A ..	100	68	100	100 ^a
B ..	100	25	100	80
C ..	100	9	100	58
D ..	52	nil	86	42
E ..	24	nil	54	32
F ^c ..	46	2	50	28
G ^c ..	49	nil	51	5
H ..	43	1	51	4
J ..	b	24	b	80
Control ..	0	0	0	0

(a) Reached after 12 applications.

(b) Not available at the time the trial was conducted.

(c) Tested at a strength below the recommended minimum.

The most interesting point brought out by this table is that the order of merit that was drawn up on the basis of the 1947 results is fully confirmed by the 1948 trials. That this should be so may be taken as evidence of the reliability of the method of assessment employed, and of the accuracy with which the Field Assistants who were engaged on this work recorded their observations. The lower standard of performance of all the fungicides in 1948 is to be attributed to the more difficult conditions under which the second trial was conducted, the density of the undergrowth on this occasion being far greater

than it had been in the previous year. There is also a possibility that the disease can be brought under control more quickly when the tapping, and consequently the treatment, is daily (as it was in 1947), than when it is alternate daily.

The final evaluation of a fungicide must take into account not only efficacy but price, and in the arrangement which has been drawn up below both these factors have received consideration.

TABLE XV. *Comparison of approved fungicides*

Relation between efficacy and price at a concentration of 5 per cent.

Fungicide	Efficacy after 14 applications		Price per gallon
	1947	1948	(cents)
A ..	100 ^a	100 ^b	16.00
J ..	not tested	80	18.00
B ..	100 ^a	80	22.00
C ..	100 ^a	58	18.50
D ..	86	42	15.00
E ..	54	33	15.75
F ^c ..	50	28	16.50
G ^c ..	51	5	22.00
H ..	51	4	22.00

(a) Reached after 7 applications.

(b) Reached after 12 applications.

(c) Tested at a strength below the recommended minimum.

As has been mentioned previously in this report, in considering the results of this comparative trial of approved fungicides it should be borne in mind that all were tested at the same concentration, namely 5 per cent. in water, which in the case of two of them was below the recommended minimum. Nevertheless such surprising differences in effectiveness have been brought to light that it seems necessary to consider whether the inclusion of some of these preparations in the list of approved fungicides can still be justified.

Field trial of a new proprietary tar acid emulsion. White Kerol, a tar acid emulsion submitted by Imperial Chemical Industries, has been tested in the field at concentrations of 3 and 5 per cent. Despite the promise shown in the *in vitro* tests, its performance in the field has been poor at both strengths. After 14 alternate daily applications its efficacy was rated as

follows:—At 3 per cent. concentration—nil; at 5 per cent concentration—31 per cent. Further tests with this preparation do not appear to be warranted.

(4) OTHER PANEL DISEASES

General Observations. A mild attack of white fan blight—a comparatively rare panel disease caused by a species of *Marasmius*—which occurred on the Experiment Station in Field 35, was easily brought under control by spraying with one of the approved tar acid fungicides.

Five strains of bacteria isolated from what was diagnosed as a severe case of black stripe on a 9-year tree of clone Tj.1 received from an estate in Kedah, but from which we failed to recover a *Phytophthora*, were tested for pathogenicity by inoculation into the bark of some Tj.1 trees of a similar age on the Institute's smallholding. All proved incapable of invading healthy cortical tissue.

Pathogenicity of the Fusarium associated with Ceratostomella fimbriata. Experimental inoculations have been carried out with the unidentified species of *Fusarium* which is frequently found growing in association with *Ceratostomella fimbriata* on tapping panels affected with mouldy rot. Some doubts as to the status of this organism (which is generally regarded as a saprophyte) have been aroused by the fact that, on one or two occasions, it has been the only fungus demonstrated in specimens of bark taken from panels exhibiting symptoms of mouldy rot. Three isolations of the *Fusarium* (derived from three different estates) were used in the experiment. Following inoculations with two of these cultures a conspicuous white bloom developed on the recently tapped surface of all the treated trees, but in no case did this growth result in anything more than a purely superficial necrosis. However since this experiment happened by mischance to have been initiated at the start of an unusually dry spell, it will be necessary to repeat it during more appropriate weather before any conclusion can be drawn.

III. Secondary Leaf-fall

General Observations. From an analysis of the monthly reports received from the Smallholders' Advisory Service it would appear that wintering had set in over most of the country by the middle of January, though, rather unusually, it was not much in evidence in the extreme north of the Peninsula until about a fortnight later. It progressed fairly rapidly in Kelantan, Kedah, Province Wellesley and northern Perak, but

tended to be delayed elsewhere by unseasonable weather. However, despite this check, refoiliation was well advanced in most districts by the end of March and virtually complete by the end of April, though it dragged on in some places until May.

During this period of refoiliation outbreaks of secondary leaf fall are known to have occurred in every State and Settlement in the Federation other than Trengganu and Pahang. On the whole the attack again appears to have been mild, less than 4 per cent. of the outbreaks brought to our notice being described as "severe."

At the end of December, 1947, a circular was sent to all proprietors and managers of rubber estates in Malaya drawing their attention to the desirability of keeping these annual epidemics of secondary leaf fall under close observation. With this aim in view they were requested not only to report any outbreaks of this disease that they might encounter, but to enclose with their reports representative specimens of infected leaves for confirmatory diagnosis. Similar notices were distributed to the Smallholders' Advisory Service. As a result of this action the presence of secondary leaf fall was subsequently confirmed on 128 estates and smallholdings distributed as follows:—

TABLE XVI. *Distribution of known outbreaks of secondary leaf fall*

State or Settlement	Number of outbreaks
Kedah ..	12
Kelantan ..	7
Penang and P. Wellesley ..	31
Perak ..	32
Selangor ..	25
Negri Sembilan ..	12
Malacca ..	5
Johore ..	4

It is, of course, impossible to say how accurately this record reflects the true prevalence of the disease; but we have grounds for supposing that some estates were still inclined to ignore it in spite of the circular they had received.

Seven further outbreaks of secondary leaf fall were reported after the main period of refoiliation was over. Two of these occurred in Pahang (one in July and one in October); two in Negri Sembilan (in July and September); one in Selangor in October; and one each in Malacca and Johore in August. The first case from Pahang was due to an attack by *Gloeosporium alborubrum* and the yellow tea mite (*Hemitarsonemus latus*), and the second to an attack by the *Gloeosporium* alone. Clone Tj.1

was involved (with other clones) in four of these outbreaks, and Tj.16 in three.

(1) STUDIES ON THE ASSOCIATED PARASITES

Observations on the incidence of the parasites. Examination of 162 representative specimens forwarded for confirmatory diagnosis between January and June yielded the following information concerning the incidence of the four parasites associated with the main annual epidemic of secondary leaf fall.

TABLE XVII. *Incidence of parasites associated with 162 cases of secondary leaf fall*

		Percentage of cases in which	
		Present	Unassociated*
Oidium heveae	..	89	24
Hemitarsonemus latus	..	68	5
Gloeosporium alborubrum	..	27	2
Scirtothrips dorsalis	..	0.6	nil

* i.e., unassociated with any of the other three parasites.

Although the above figures show that only 24 per cent. of the cases could be attributed to *Oidium heveae* alone, they make it fairly evident that this parasite was the one principally responsible for the epidemic.

Observations on Oidium heveae. Some young seedlings maintained in pots in the laboratory became infected with *Oidium heveae* during the last week of October. The attack was quite indiscriminate, affecting both surfaces of young and fully formed leaves alike. The development of the colonies caused some local discoloration and distortion of the tissues, but none of the infected leaves was shed. Six weeks after the attack had started, it was still possible to obtain a few viable conidia from some of the colonies, though by this time the majority were dead.

This was the second occasion during the year when potted laboratory seedlings were found to be infected by *Oidium*, the first case having occurred early in February. It is an interesting reflection that both these attacks took place, if not on dry leaves, at least on leaves on which dew can never have formed.

As *Oidium heveae* was observed occurring in an active, sporulating condition (either on mature trees or on young

seedlings) during eleven out of the twelve months of 1948, we are beginning to wonder whether the reason why no one has ever been able to discover any dormant stage in its life history is because none exists. The suggestion being that, in reality, this fungus maintains a continuously active existence, most of the year being passed in an inconspicuous manner on the leaves of self-sown seedlings and on the occasional new flush produced by mature trees; and that it suddenly becomes prominent during periods of general refoliation not because it is then resuming activity after an interval of dormancy, but because its rate of reproduction is enormously increased at this particular juncture by the presence of vast quantities of suitable host tissue.

Observations on the other associated parasites. An account of further studies on *Hemitarsonemus latus* and *Scirtothrips dorsalis* will be found recorded under sections X and XI.

(2) STUDIES ON VARIATIONS IN CLONAL RESISTANCE

Effect of sulphur-dusting on defoliation in clone B.D.5. Throughout Malaya clone B.D.5 suffers from a form of chronic defoliation which is associated characteristically with an infection of the leaves by *Gloeosporium alborubrum*, the fungus being accompanied not infrequently by *Hemitarsonemus latus*. However, since the general experience has been that this defoliation fails to respond to dusting with sulphur, it has been assumed that neither the fungus nor the mite is primarily responsible for the condition. With the object of determining to what extent this conclusion is justified it was decided (in conjunction with the Botanical Division) to subject part of a large block of B.D.5 at Sungei Buloh to regular and heavy applications of sulphur over an extended period; and to follow up the effect of this treatment by comparing the canopy densities of an equal number of treated and untreated trees at monthly intervals by means of a photographic adaptation of the grid method described by Haines.*

The experiment was started early in April, and by the close of the year thirty-five approximately weekly applications of sulphur at the heavy rate of 40 lb. per acre had been made without producing any significant improvement in the condition of the foliage.

* Haines, W.B. *Empire Journ. Exp. Agric.* 1942, 10, 117-124.

IV. Leaf Diseases of Young Plants

(1) BIRD'S EYE SPOT (*Helminthosporium heveae*)

General Observations. The severity of the damage inflicted in seedling nurseries by the outbreak of bird's eye spot which first became prominent towards the end of 1947 continued to arouse concern. A particularly notable case occurred on an estate in Selangor where, in a ten-acre nursery of clonal seedlings, every plant without exception had been heavily attacked and was suffering from severe defoliation. When first seen these seedlings were from four to five months old, and the freedom from infection of their lowest, first-formed whorls of leaves illustrated very clearly the rapidity with which these epidemics of bird's eye spot can be built up in a closely planted nursery.

Mycological Studies

Observations on the viability of the conidia. The viability of the detached conidium of *Helminthosporium heveae* is in the course of being determined by means of germination tests carried out at three-monthly intervals. The conidia set aside for these tests are being stored under air-dry conditions on the leaves on which they were produced. The sample examined at the end of the first three-months storage gave 100 per cent. germination in a hanging drop.

The formation of chlamydospores and of appressoria. The formation of what appear to be rounded chlamydospores has been observed in a three-months-old hanging drop culture grown from a single conidium. *Helminthosporium heveae* has generally been regarded as possessing only one form of spore—the characteristic boat-shaped macroconidium—and if it is confirmed that these bodies are in fact resting spores, this finding may prove to be of importance.

The formation of appressoria has been observed when conidia have been germinated on glass slides in distilled water.

The existence of other spore forms. The pathogen of bird's eye spot is known only in the conidial stage, but, since the genus *Helminthosporium* contains several species which are the imperfect stages of ascomycetous fungi, the possibility exists that *H. heveae* may occur in another form, either on rubber or on some alternate host. Should this be so, the importance of identifying this other stage is obvious. The problem is being approached in several ways. Attempts are being made to induce the formation of fruit-bodies in culture; and any pycnidia or

perithecia found growing in association with *H. heveae* are being subjected to close study. A species of *Mycosphaerella* and a pycnidial fungus, already observed occurring in this situation, were under examination at the close of the year.

Influence of various environmental factors on growth in culture. Observations are being made of the effect on the growth of the fungus of the nature of the substrate, and of light and temperature. Ten agar media have already been employed in this study. One some of these (notably potato-dextrose agar) the absence of light appears to have stimulated growth; while on others (*e.g.* corn meal agar) the effect has been to retard it. The rate of growth has been consistently most rapid (under all conditions) on Dox, oat meal and rice polishings agars. The nature of the substrate was found to have a marked effect on sporulation, conidia being produced most freely not on an agar medium, but on sterilized, decorticated *Hevea* twigs.

Pathological Studies

Dissemination of the disease. All available evidence suggests that the disease is spread by air-borne spores. In an attempt to gain information on this point a spore-trap was constructed and set up in an infected nursery at Sungei Buloh. Few spores of *H. heveae* were caught over a period of several days. Whether this result is to be attributed to an actual scarcity of air-borne spores or to imperfections in the apparatus has yet to be determined.

Conditions favouring infection. Nothing is known of this important aspect of the subject. There is what may be called a tradition in Malaya that the disease is favoured by dry weather. In Indo-China it is held to become more prominent during cold, wet spells. No precise evidence has been adduced in support of either hypothesis. The presumption is that the presence of a film of water on the surface of the leaf is necessary for the germination of the conidium; and it would seem immaterial whether this film has been produced by rain or dew. A heavy dew, however, is likely to favour infection more than a heavy rain, since the latter will tend to wash the conidia off the leaf; and heavy dews may be expected to occur more frequently during dry cloudless weather. All these hypotheses are being submitted to examination.

Observations in this country and in Ceylon have suggested that seedlings grown in shade are less susceptible to the disease than those grown in the open. In what way shade produces this effect is, again, not known. To provide us with

a means of studying this question, a nursery has been set up under the shade of a small plot of mature rubber which immediately adjoins a 75-acre nursery recently established at Sungei Buloh; and it is also proposed to cover over about half-an-acre of this main nursery area with an attap roof raised about seven feet from the ground.

An inspection, carried out at the end of the year, showed that while the seedlings planted under the shade of the mature trees were still quite free from bird's eye spot, those of the same age growing in close proximity in the open were already becoming infected.

Mode of infection. A method of inoculation with a single spore so as to observe the subsequent process of spot formation has not yet been devised. Typical spots have been obtained, however, by inoculating leaves, 2 cm. long, with a spore paste. Spraying with a suspension of spores derived both from natural sources and from culture has not been successful.

Germinating spores with their germ tubes applied closely to the leaf can be seen readily in surface view by staining, but whether penetration is through stomata, hydathodes, or by piercing of the cuticle has yet to be determined. The fact that appressoria have been demonstrated in the laboratory, and the presence of a distinct swelling at the point of penetration of an invading germ tube suggest the latter.

Source of infection. The repeated presence of a germinating macroconidium on the site of a primary lesion shows these spores to be responsible for most, if not all, infection. That they are generally disseminated by air currents seems most probable.

Investigations carried out by La Rue in Sumatra led him to conclude that the initial source of infection for a newly established nursery was provided by sporulating lesions present on the leaves of mature trees. So far we have been unable to confirm this observation. Indeed, despite the examination of many hundreds of leaves derived from mature trees in all parts of Malaya, we have not yet found any that have been infected with *H. heveae*.

We have evidence that sporulating lesions can occur throughout the year on young rubber seedlings. It is obvious therefore that, given the right circumstances, these could easily initiate outbreaks. But it is difficult to see how such a source could be held responsible for the infection that was starting in the new 75-acre nursery at Sungei Buloh towards

the end of the year. The disease in this nursery has been kept under constant observation since it first appeared, and it is well established that at least one point of origin was a boundary bordered by an extensive forest reserve. There is thus a very strong suggestion that the source in this instance was either some forest tree, or one of the many species of plants growing as weeds along the margin. A systematic examination of all nursery weeds exhibiting any signs of infection is in progress.

Development of improved methods of control

Field trial of fungicides and insecticides. In the annual report for 1947 mention was made of the fact that an experiment, whose object was to explore the possibilities of finding a more effective method of controlling bird's eye spot than the customary dusting with sulphur, had been laid down at Sungei Buloh at the end of November and was still in progress when the year ended. This experiment was finally brought to a conclusion in May of the year now under review. As originally planned it had been designed to test seven proprietary preparations; these being as follows:—

Sprays: *Perenox* (50% Cu as Cu_2O) used at 2-lb. to 100 gallons; *Wettable Sulphur* at 2-lb. to 100 gallons; D.D.T. as a 0.1% emulsion.

Dusts: *Triocide* (2.5% Cu as oxychloride, 3% D.D.T., 88% sulphur; *Perelan* (17% Cu as Cu_2O); *De De Tane* (5% D.D.T.); *S. S. Sulphur*.

The treatments were applied in duplicate to one-fiftieth-acre plots, each of which contained about 200 seedlings and was surrounded by an adequate number of guard rows. Provision was made for control plots. The first round of spraying and dusting was carried out on the 25th November when the seedlings were about seven weeks old and already infected with *Helminthosporium*, the sprays being applied at the rate of 10 gallons per acre and the dusts at 25-lb. After five fortnightly applications had been made at these rates without obvious beneficial effect resulting from any treatment, the interval between applications was reduced to a week. Six applications at this frequency, even though made at the increased rate per acre of 15 gallons for the sprays and 36-lb. for the dusts, also failed to make any visible impression on the disease.

The height of the plants in each plot had been measured at the start of the experiment and then subsequently at monthly intervals with the idea of estimating the value of

the various treatments by comparing their general effects on growth. Statistical analysis of the data derived from these measurements indicated that the rate of growth had been increased by treatment with Perelan and retarded by treatment with 0.1 per cent. D.D.T. emulsion. None of the other treatments had produced any significant effect.

At this point the experiment was reviewed and the following conclusions reached:—

(a) that the unqualified failure of all the treatments to secure control of the disease might have been due to the size of the plots, which were so small in relation to the total area of the nursery that they were submerged in a mass of diseased plants and thus subjected to constant re-infection.

(b) that mites and other pests were of such minor importance compared with the *Helminthosporium* that the use of insecticides was probably quite unnecessary.

(c) that the rate of application of the sprays was too low to be effective, and that of the dusts too high to be economic.

On the basis of these conclusions it was decided to re-plan the experiment. The plots were enlarged to one-sixth of an acre each to ensure that the central group of 200 seedlings, from which measurements were to be taken, would no longer be surrounded by an expanse of untreated plants; and two of the D.D.T. formulations together with Perelan were discarded, the latter only because of a temporary exhaustion of local stocks. We were thus left with four preparations: two sprays:—Perenox and Wettable Sulphur; and two dusts:—Triocide and S.S. Sulphur. However, after ten weekly applications had been made with the sprays at 25 gallons to the acre and with the dusts at 20 lb. it was again quite evident that no appreciable control was being obtained with any of the treatments.

The extraordinarily poor performance of all the fungicides used in this trial was difficult to account for, since at least four of them had been well proved in other parts of the world—not against bird's eye spot in particular, but against a variety of other plant diseases. And, assuming that it was not due to actual inability to inhibit the germination of the *Helminthosporium* spore, it seemed that this ineffectiveness must have been associated either with the difficulty of covering the under surface of the rubber leaf when it is at its most susceptible stage, that is when it is pendant; or with the excessive leaching which is a consequence of our heavy rains.

Evaluation of wetting and sticking agents. As the conclusion drawn from the experiment which has just been described was that the poor performance of all the fungicides used in it might well have been due either to inadequate coverage or to lack of tenacity, it clearly seemed desirable that the effect of wetting and sticking agents should be studied in the next season's trials. But as so little attention has been paid to this subject in tropical countries it was evident that some preliminary sorting would be necessary before we could judge what type of agent would even be worth trying under Malayan conditions. Admittedly Langford's work on South American leaf blight in Costa Rica had shown that the effectiveness of a copper fungicide could be increased by the addition of 0.05 per cent. casein*, but casein was quite unobtainable at the time that the tests now to be recorded were planned. Six proprietary substances were however available, namely:—Teepol and Lissapol N (both wetting agents); Agral 2 (described as a wetter and spreader); Albolineum and Goodrite P.E.P.S. (both recommended as stickers); and Tragon A (a gum). To this list were added fresh latex and ammoniated latex.

The plan of the experiment was to incorporate these substances, in suitable proportions, in a copper fungicide, and to determine their effects on coverage and tenacity by estimating the amount of copper initially deposited per unit area of leaf, and the amount retained after a heavy fall of rain. Perenox, at a strength of 4 lb. to 100 gallons, was chosen for the test.

Each formulation was sprayed on to a set of four potted rubber seedlings with the aid of a small pneumatic hand sprayer, each plant receiving the spray for a timed period of two seconds. When the spray deposit was dry, one complete leaf (i.e. three leaflets) was removed from each plant and the four samples brought into the laboratory for analysis. A second set of leaves was collected on the day after spraying, following a rainfall of 2.59 inches.

The method of copper determination employed in this study was essentially that described by Large, Beer and

* Langford, M.H., U.S.D.A. Circular No. 686, 1943.

Patterson under the name of the "battery washing method"* This consists, briefly, in removing the copper from the leaves by washing in dilute aqua regia, and estimating it colorimetrically with sodium diethyldithiocarbamate in a Spekker absorptiometer. The Chemical Division collaborated in this phase of the work.

To enable the results to be expressed per unit area, the area of each set of leaves was determined by comparing its total weight with that of a known area of leaf composed of ten samples of 10 sq. cm. each which had been cut from ten random leaflets.

TABLE XVIII. *Effect of sticking and wetting agents on the amount and tenacity of the copper deposit produced by spraying with 4 : 100 Perenox*

Agent added to 4 : 100 Perenox	Cu in mgm. per 100 sq. cm. of leaf surface		Percentage copper retained
	In initial deposit	After 2.59" of rain	
Control (no addition) ..	2.08	0.06	3
0.5% Teepol ..	0.48	nil	nil
0.5% Lissapol N ..	0.30	0.11	38
0.125% Agral ..	1.69	0.48	28
0.05% Albolineum ..	1.31	0.63	48
0.2% P.E.P.S. ..	2.24	1.07	49†
0.5% Tragon A ..	1.42	0.37	26
0.02% Fresh latex ..	1.74	0.70	40
0.2% Ammoniated latex ..	1.55	0.91	59

† There is evidence that this figure is too low. Visual observations having indicated that the aqua regia solvent had failed to remove all the copper, the washed leaves were ashed (together with an unsprayed control), and an estimation made of the residual copper. This showed that the true figure for retention was about 60%. It remains to be determined whether the insolubility of the deposit resulting from the use of P.E.P.S. will lead to a reduction in fungicidal value.

* Large, E. C., Beer, W. J. and Patterson, J. B. E., *Ann. Appl. Biol* 1946, **33**, 54-63

The following inferences may be drawn from the data presented above:—

(a) that Perenox produces a good initial deposit, but is insufficiently tenacious for use in an unmodified form under Malayan conditions.

(b) that the addition of wetting agents will tend to have an adverse effect on deposit by increasing run-off; and may in some cases (*e.g.* Teepol) have a most serious effect on tenacity.

(c) that of the eight agents studied, Albolineum, P.E.P.S. and fresh and ammoniated latex are certainly worthy of a further trial.

In view of the adverse effects produced by wetting agents, it seems that it might be better to aim at achieving good coverage by finer atomization of the spray than by attempting to reduce the surface tension of the drops; although there still remains the possibility that a favourable result might be obtained with a suitable combination of wetting agent and sticker.

Trials of applicators. Efficient application of a fungicide or insecticide is a far more important matter than is commonly realised. For the treatment of a nursery leaf disease such as bird's eye spot small sprayers or dusters are called for, since the size of the average nursery is such that use of the larger and more powerful machines that are the result of modern developments is out of the question. Among the applicators at present available locally, the variety of which is extremely limited, pneumatic knapsack sprayers and hand operated rotary dusters are the best suited for this sort of work. Most of the former, however, suffer from the disadvantage that if they are of the right capacity (4 to 5 gallons) they are far too heavy when fully loaded for use by the average Tamil labourer. Furthermore it is doubtful whether the actual working pressure of the general run of these machines is high enough to overcome the difficulty of covering the under surface of the young pendant leaves.

The position in regard to rotary dusters being even more unsatisfactory, we imported two Australian machines with the idea of comparing their performance with that of the only English machine readily obtainable in this country. The Australian machines, both of which differ basically from the English model in that they are fitted with external blowers, were found to be superior not only in design and construction, but

also as regards weight, capacity, rate of output, and ease of operation. The prices of all three machines were comparable.

With the aid of drawings secured through the courtesy of the Shell Company of the Federation of Malaya we have had constructed an atomizing nozzle of the type described by Hamner and Tukey*. This has been subjected to preliminary tests and found to perform well in accordance with the designers' intention to provide fine atomization combined with a low rate of delivery. We are inclined to question, however, whether the very low pressure at which this nozzle operates will not prove to be a disadvantage from our point of view.

(2) GLOEOSPORIUM LEAF SPOT (*Gl. alborubrum*)

General Observations. A few cases were brought to notice during the year where defoliation of young budgrafts in multiplication nurseries were associated with infection of the leaves by *Gloeosporium alborubrum*.

Further study of this fungus is tending to suggest that it is a variable species and not only made up of different physiologic strains, but capable at times of giving rise to a *Colletotrichum* form. Five cultures (Nos. 42, 67, 68, 69 and 70) isolated from leaves that had been collected in three widely separated localities, were sent to the Commonwealth Mycological Institute who found them to be morphologically indistinguishable.

Attempts to infect young leaves by inoculating them with spore suspensions derived from two of these cultures (Nos. 42 and 69) have proved unsuccessful.

(3) OTHER LEAF DISEASES OF YOUNG PLANTS

Anthracnose. Anthracnose of rubber, which is caused by *Colletotrichum ficus* (said to be the imperfect stage of *Glomerella cingulata*), seems to have attracted little attention since it was first recorded in the Far East some thirty years ago; yet peculiarly enough several outbreaks of this disease came under observation towards the end of the year. One of these occurred during September in a field of three-weeks-old clonal seedlings in Negri Sembilan and caused some concern.

The disease is characterized by a striking concentric zonation of the lesion. Inoculation of young leaves with a spore suspension derived from a culture (No. 126) of the pathogen isolated from the case in Negri Sembilan failed to

* Hamner, C. L. and Tukey, H. B., *Science* 1947, 105, 104-105

reproduce this symptom, giving rise only to a few very small circular brown spots.

Cephaleuros mycoidea. This alga has frequently been found causing blue-black spots on the senescent leaves of young seedlings and mature trees.

V. Defence against South American Leaf Blight

General Observations. The introduction of South American leaf blight (*Dothidella ulei*) into the rubber cultivations of the Far East might be an event fraught with the most grave and far-reaching consequences. Indeed, since past experience in the Guianas and Central America with material imported from Malaya and neighbouring territories has given ample proof of the extreme susceptibility of the rubber grown throughout the East, it is a reasonable presumption that were the disease to become established in this region, and to display the degree of virulence that has characterized its appearance in American plantations, the sequel might well be the ruin of the rubber industry.

The risk of South American leaf blight being introduced into Malaya has been so enhanced by the increasing volume and speed of international air traffic that steps were taken by the Department of Agriculture early in the year to strengthen the Rules governing the importation of plants into this country; and in this connexion the Head of the Pathological Division collaborated with the Senior Plant Pathologist, Department of Agriculture, in the framing of certain new regulations specifically designed to exclude this disease.

It has naturally been realised that such unilateral action cannot itself provide a complete safeguard; for should the disease appear anywhere in South-East Asia (and succeed in eluding eradication) it would be the height of optimism for any country to suppose that a local system of legislative control could continue to prevent the infection of its own cultivations. It is therefore clearly in the common interest of all rubber-growing countries in this region to ensure that the necessary protective measures are made operative throughout the area. At the close of the year this aspect of the matter was receiving the attention of the Commissioner-General's Office in Singapore.

(1) INVESTIGATION OF METHODS OF ERADICATION

While there is every reason to hope that the measures already taken, and others now in prospect, will succeed in

their object of keeping South American leaf blight out of the South-East Asian region, ordinary prudence demands that a study should be made of methods that could be brought into operation to deal with any outbreak that might occur.

For such a dangerous disease as this the orthodox methods of control are quite inadequate, and the aim must be to eradicate it completely by destroying all infected plants. Two ways of bringing about the rapid destruction of plants are open to consideration; the first being by the application of phytotoxic sprays and the second by the use of flame throwers. It is our intention to investigate both methods; and for this purpose a special nursery area of about three acres has been planted at Sungei Buloh to provide us with a testing ground. Two knapsack flame-throwers were acquired during the course of the year (one of American and the other of Australian manufacture), and these have already been given preliminary trials. A third machine has been ordered from England.

The kind of applicator—whether flame-thrower or sprayer—that would be suitable for use against nursery seedlings (or even young trees) would not, of course, be of the slightest value in stands of mature rubber, and the only solution to the problem of eradicating the disease from such areas would seem to lie in destructive spraying from the air. The trials that are to be carried out at Sungei Buloh will enable us to decide, in due course, what is the best type of spray for an aircraft to use for this purpose.

(2) INVESTIGATION OF PROCEDURES DESIGNED TO ENSURE THE FREEDOM FROM DISEASE OF IMPORTED PLANTING MATERIAL

As a condition of granting a permit for the importation into Malaya of rubber planting material grown in other parts of the South-East Asian region, the Director of Agriculture has ruled that all such material must be disinfected with a suitable fungicide before being packed*. Dusting sulphur has been specified for this purpose (both for seed and for budwood) on the strength of tests carried out before the war. However, since it is conceivable that among the many other fungicides now available there exist some that would be superior to sulphur as regards both their fungicidal efficacy and their effect on the viability of the planting material, a series of observations have been started to investigate this point. As a

* In the event of a permit being granted for the importation of rubber planting material from outside the South-East Asia region, more stringent precautions than these would be required.

beginning, the various treatments are being judged solely on the latter basis. An account of some experiments with budwood carried out during the last quarter of the year follows immediately below.

Observations on the disinfection of budwood. The effect of prior disinfection with five fungicides on the viability of the packed budwood of clones R.R.I. 506 and Tj.1 has been studied by means of an experiment carried out in collaboration with the Botanical Division. The opportunity was also taken of comparing the effects of two forms of packing (sacking and coconut fibre) and of two forms of sealing (Entwax and 2295-1A grease). The five fungicides used (all of which were dusts) were as follows: S. S. Sulphur; Zerlate; Perelan (17% Cu); copper carbonate (55% Cu); and copper oxychloride (50% Cu).

Twenty-four yards of budwood from each clone were employed in this test; four yards being dusted with one of each of the five fungicides and four yards being retained untreated as a control. The cut ends of one half of this yardage were sealed with wax and of the other half with grease. The budwood representative of each fungicidal treatment was divided into two lots, one lot being packed in a wooden box with moist coconut fibre and the other lot in a separate box with damp sacking. The total of twelve boxes was then stored for nine days. At the end of this period the budwood was unpacked, washed and passed to the budders, who were instructed to aim at budding ten buds from each yard. The number of budgrafts that had become successfully established was determined by an inspection carried out 23 days later. The results of this inspection are recorded in Table XIX. The conclusions to be drawn from this table are:—

(a) that copper compounds have a deleterious effect on the viability of the buds, and are therefore unsuitable for use in the disinfection of budwood.

(b) that Zerlate is as innocuous as sulphur and may safely be substituted for it.

(c) that although there were no striking differences in the results obtained with the two methods of the sealing the trend is in favour of wax.

(d) that, judging more particularly by the results obtained with the untreated controls, coconut fibre is the preferable packing material.

TABLE XIX. *Disinfection of Budwood*
Effect of fungicidal treatments and of methods of sealing and packing on the viability of the buds

Percentage of Successful Budsings *

(G = grease; W = wax; M = mean)

(a) *Budwood packed in coconut fibre*

Clones	Sulphur			Zerlate			Perelan			Cu carbonate			Cu oxychloride			Control		
	G	W	M	G	W	M	G	W	M	G	W	M	G	W	M	G	W	M
R.R.I. 506	80	100	90	80	80	80	20	30	25	0	10	5	0	0	0	100	100	100
Tj. 1	100	90	95	90	100	95	0	0	0	20	0	10	10	30	20	100	100	100
Means	90	95	—	85	90	—	10	15	—	10	5	—	5	15	—	100	100	—

(b). *Budwood packed in sacking*

R.R.I. 506	100	100	100	70	90	80	0	50	25	20	70	45	50	20	35	80	70	75
Tj. 1	60	70	65	100	100	100	0	0	0	20	20	20	0	0	0	100	90	95
Means	80	85	—	85	95	—	0	25	—	20	45	—	25	10	—	90	80	—

* Based on a figure of ten budgings per clone per treatment, irrespective of whether the quota of ten suitable buds was actually secured.

Not only were the copper containing fungicides found to have an adverse effect on the viability of the buds, but they also seemed to make them brittle and difficult to strip; this being most noticeable in the case of Perelan.

VI. Stem and Branch Diseases

(1) PINK DISEASE (*Corticium salmonicolor*)

General Observations. Pink disease appears to have attracted very little attention during 1948. The only outbreaks which caused sufficient concern to lead to an enquiry were two that occurred in stands of very young rubber. That the disease must still be prevalent would seem to be evidenced by the fact that its incidence in the six-to ten-year-old rubber at the Experiment Station (where it is subjected to regular rounds of treatment) ranged during the year from 4.6 to 6.6 cases an acre. Against this, however, are to be placed the records of the Smallholders' Advisory Service which show that it was observed to be present in only 1 per cent. of the 46,000 holdings visited during the same period.

Following on the observation that stands of young rubber that had been planted in districts previously notorious for the disease had come to no harm despite the neglect of the war years, several experienced planters reached the conclusion in 1946 that not only was it unnecessary to take any action against pink disease in the future, but that the regular application of the orthodox methods of control had, in all probability, actually been responsible for aggravating it in the past*. We do not yet know whether this view is correct, but it is certainly beginning to seem that the amount of notice pink disease attracts is directly proportional to the amount of labour available for treating it. As soon as our records of the incidence of this disease at Sungei Buloh are sufficiently complete, which should be the case by the end of 1949, we propose to put the hypothesis to a test by ceasing treatment in a proportion of the fields and then noting the subsequent effect.

(2) PATCH CANKER (*Pythium* and *Phytophthora* spp.)

General Observations. Only one case of patch canker was brought to notice during the year. This occurred on an estate in Negri Sembilan. Isolation of the pathogen was not achieved.

* See Ann. Rept. R.R.I.M. for 1946, p. 107.

(3) DISEASES OF YOUNG SHOOTS

Introduction. Under this head are included the infectious diseases of all green terminal shoots, whether produced by young seedlings or budgrafts or by the woody branches of trees. Such diseases belong to the group known as "die-backs", but as this term is frequently applied to pathological conditions that are not due to stem infections at all it is inadvisable to use it for the purposes of classification without strictly defining the type of disease to which it refers.

Die-backs associated with Gloeosporium alborubrum. The majority of the cases of die-back in young seedlings and budgrafts encountered during the year were associated with infection of the stem by *Gloeosporium alborubrum*. In two instances the cultures isolated from the brown lesions (No. 63 from a field planting of 7-months old seedlings in Malacca, and No. 127 from young budgrafts in a multiplication nursery in Negri Sembilan) were subsequently observed to give rise to setae, that is to assume the form of a *Colletotrichum*. Experimental inoculations with the former resulted in the production of a few small elongated spots, but no die-back occurred. The fungus was later re-isolated from one of these artificially produced lesions.

Die-back associated with species of Phytophthora. Only one case of die-back was shown (by recovery of the pathogen) to be due to infection by a *Phytophthora*. This occurred in a field planting of young budgrafts in Selangor. The fungus (No. 47) has since been identified as *Phytophthora heveae**.

(4) OTHER STEM AND BRANCH DISEASE

Die-back of woody branches associated with infection by Fomes noxius. A most interesting case of a die-back involving the main branches (and in some instances even the stem) of 10-years-old trees of clone Tj.1 which was found to be due to an infection by *Fomes noxius*, was observed on a smallholding in the Klang district of Selangor. The pathogen, which was isolated from the cortex at the advanced margin of the rot, had evidently gained entry through wounds caused by wind damage. This observation provides further proof that *Fomes noxius* can be spread by air-borne spores.

* We are indebted to Mr. A. Thompson, Senior Plant Pathologist, Department of Agriculture, Malaya, for the identification of this species.

VII. Injuries of Non-Parasitic Origin

Internal fissures. Symptoms appearing on the tapping panels of trees of clone G.1 on an estate in Negri Sembilan, which were at first thought to be caused by an outbreak of black stripe, were subsequently recognised as being due to the presence in the bark of internal fissures of the type originally described by Sutcliffe†. This is the second occasion on which this form of injury has been observed in clone G.1, a case from Selangor having been reported last year.

Bark-bursts. The name "bark-burst" has come to be used for a type of injury which is characterised by a longitudinal splitting of the bark that is usually accompanied by an exudation of latex. Work carried out both before and since the war has consistently failed to produce any evidence of a causal relationship between the development of such injuries and the activities of a pathogen; and the view generally held is that they are the result of internal strains set up in the cortex, either by wind or by unbalanced growth. However, so little is actually known about their cause that it remains open to question whether all "bark-bursts" have in fact a common origin.

Some clones seem to be more liable to this form of injury than others. The three cases brought to notice during the year involved trees of clones P.B. 86, P.B.23 and G.1.

Sun-scorch. Sun scorch is a form of heat injury that young, newly transplanted seedlings are subject to if they are removed without prior hardening from the shade of a nursery to the full glare of the sun in a field. The plants may be affected in two ways: the chlorophyll of the leaves may be destroyed with the result that the leaflets lose their green colour, become attacked by a number of weakly parasitic fungi, and eventually fall; or the cortical tissues of the stem at a point an inch or so above soil level may be damaged and thus laid open to invasion by *Botryodiplodia theobromae*. If the injury is confined to the leaves the seedling commonly recovers; but if the stem is involved it dies. Both symptoms have been reproduced experimentally by fixing a concave metal reflector around the base of young plants, which had been previously grown in the shade, and then exposing them to the sun. No result was obtained when the metal reflector was replaced by a concave soil surface covered with fine white sand. It is possible, however, that this failure may have been due to the use of older plants.

† Sutcliffe, H., *J. Rubb. Res. Inst. Malaya* 1930, 2, 12-15.

During the year, the following fungi were observed growing on leaves that had been blanched by sun-scorch:—*Aposphaeria heveae** (the *Torula* stage only), *Phyllosticta* sp.*, *Curvularia maculans**; *Curvularia geniculata**; *Cladosporium herbarum*, *Alternaria* sp., *Periconia* sp., *Diplodia* sp., and a fungus provisionally identified as a species of *Macrosporium*.

Sodium arsenite injury. The widespread use of sodium arsenite on rubber cultivations (which is largely a post-war development) is bringing in its train numerous instances of accidental poisoning of the crop. One feature common to nearly all these cases is that nobody in authority appears to have had the slightest idea of what caused the injury. The first thing they are aware of is that on one or more trees a localized area of bark, or a long vertical strip, is exuding latex; probably being attacked by borers; and clearly dying. The reason for the air of mystery that overhangs most of these occurrences is easier to understand when one considers how they come about; which is in one of the following three ways:—

(a) by using sodium arsenite for thinning-out a young stand. Now whereas this practice appears to be a perfectly safe one on some soils, on soils where root-grafts are prevalent the sodium arsenite is drawn by the pull of the transpiration streams from the poisoned tree (which is naturally a weakling) into those of its neighbours to which it is joined.

(b) by the careless handling of sodium arsenite sprays during weed eradication, whereby the poison is brought into direct contact with the stems of the rubber trees.

(c) by the spilling of vessels containing solutions of the poison, with the result that some of the large excess which cannot be fixed by the soil is taken up by the roots of the trees.

When the injury has been brought about in the last mentioned manner there is nothing surprising in the fact that no-one should be aware of its cause, for it would be expecting too much to suppose that the labourers responsible would report the accident. But in the other two cases, where it must be known that sodium arsenite has been used in the field in which the damage has appeared, one might be justified in thinking that some suspicion as to the origin of the trouble would have been aroused. That this should rarely occur is, perhaps, because sodium arsenite has now been used for weed eradication and thinning-out so often without untoward effect that there

* We are indebted to the Commonwealth Mycological Institute for the identification of these fungi.

is a tendency to forget that neither operation is entirely free from risk. Fortunately, not only are we now able to diagnose arsenic poisoning with some confidence from its macroscopic symptoms, but in any questionable cases a chemical analysis settles all doubts.

VIII. Termites

Taxonomic note. Reference to the paper in which Holmgren described *Coptotermes curvignathus** makes it clear that his species is not synonymous with Wassmann's *Coptotermes gestroi*, as has sometimes been stated. Although Holmgren mentions *C. gestroi* as a pest of rubber in the Far East, this species has not been found in any of the collections of termites (taken from rubber trees) that have been examined in Malaya; nor have we encountered it in the field. The confusion between the two species arose from an incorrect identification by Haviland of material collected in this country.

(1) ECOLOGICAL STUDIES

Observations on Coptotermes curvignathus. A localised outbreak of *Coptotermes curvignathus* in a new clearing on the Experiment Station, in which fifty stumps were attacked in an area of about $1\frac{1}{4}$ acres, provided a convenient site for excavation of the colony. The nest was traced to the vicinity of a large fallen jungle tree, which was then isolated by a trench and cleared of all surrounding timber. Immature stages of the insect were found on cutting the log open; but in spite of an intensive search, during which the log was split into small pieces and completely removed, the royal cell was not discovered. Whilst digging over the ground, the nests of four other species of termites were encountered. This experience illustrates how much easier it is to locate a nest constructed in the soil than one situated within a fallen hardwood tree.

Large numbers of workers, soldiers and immature stages of *C. curvignathus* that had been collected in the course of this excavation were brought into the insectary, where they might well have reformed into a reproductive colony had they not been destroyed by an outbreak of disease caused by the fungus *Conidiobolus villosus*.

Observations on other termites. A species of *Eutermes* can often be found working on the stems and branches of mature rubber

* Holmgren, N., *K. Svenska VetenskAkad. Handlingar* 1913, 50, (2), 77.

trees; but as its activities seem to be entirely confined to the removal of the superficial layers of bark, which would flake away naturally in any case, it may justifiably be regarded as harmless.

(2) EXPERIMENTS IN CHEMICAL CONTROL

Experiments with dusts liberating hydrocyanic acid. An investigation is being made of the possibilities of controlling termites by using dusts such as Cyanogas or Cymag in some form of injection technique. In the first trial Cyanogas was blown into the mudwork on the trunk (the so-called trail-injection method) with the aid of one of the pumps sold by the manufacturers of this preparation, this having first been modified to produce a finer stream of dust. It immediately became apparent, however, that this method was quite impracticable since the mudwork was too porous to retain the injected dust-laden air.

In the days before the present methods of termite control had come into vogue it had been customary (with the aid of an apparatus known as the "Universal Exterminator") to heat a mixture of sulphur and white arsenic over a charcoal fire and to pump the resultant fumes through an auger hole into the cavity of any tree that was found to have been hollowed by the termites, the notion being that such a tree would provide an ideal portal of entry to the nest. In view of the failure of the trail-injection method it was decided to give this older one a trial; accordingly about three ounces of Cyanogas were pumped into the interiors of three hollow trees that had been located at Sungei Buloh. An examination carried out a week later showed all three trees still to be infested, but (a point of considerable importance) none of them displayed any signs of having suffered any injury from the treatment.

Since we were now satisfied that Cyanogas could be used in this way with safety, and there being little scope for more extensive tests on the Experiment Station owing to the scarcity of severely damaged trees, the opportunity was taken of having the method tried out on an estate in Negri Sembilan where about 200 acres of 8- to 9-year-old rubber had been heavily attacked by termites in the past, and was now reported to contain a large number of hollow trees. The area, which carries a dense natural undergrowth, is divided into two approximately equal fields for which, fortunately, retrospective figures of incidence of attack were available at the time our

test started. The procedure that has been adopted is to treat lightly attacked trees throughout the area in the standard manner, *i.e.* with one pint of a 1 per cent. solution of mercury perchloride per tree, and to superimpose upon this treatment, in one field only, the injection of hollow trees with Cyanogas. The results of this experiment, which was still in progress at the close of the year, will be assessed on the basis of the records of incidence.

Experiments with smoke generators. The development of smoke generators containing D.D.T. and benzene hexachloride has given us an opportunity of testing these newer insecticides against termites in the manner that has just been described, *i.e.*, by what might be called the cavity-injection method. In their case, however, the Universal Exterminator was itself employed, the smoke generator replacing the charcoal fire, sulphur and arsenic that the apparatus was originally intended to contain. Introduction of the insecticidal smoke into the tree was successfully achieved, the fumes issuing through small fissures in the bark; but there was no indication of any penetration through the soil.

For the experiment with D.D.T., one 2.B Fumite smoke generator was used for each tree, five trees being treated in all. Examination after the lapse of one week revealed that three were still infested with termites. This is regarded as an unsatisfactory result, since in view of the high cost of these generators nothing less than 100 per cent. success could be considered acceptable.

The three trees which had not responded to the D.D.T. treatment were now fumigated with benzene hexachloride, the contents of one No. 2 Gammexane smoke generator being introduced in each. Once again the termite attack survived the treatment.

(3) EXPERIMENTS IN BIOLOGICAL CONTROL

Experiments with Conidiobolus villosus. Work on *Conidiobolus villosus* in 1947 showed that although this fungal parasite of *Coptotermes curvignathus* was extremely lethal under the conditions of a laboratory test, it failed to produce any perceptible effect when used in the field. All attempts to determine the cause of this peculiar behaviour were without success*.

During the year now under review an attempt was made to bridge the gap existing between *in vitro* tests and those

* Ann. Rep. R.R.I.M. for 1947, p. 127.

carried out on the tree by working with sub-colonies of the termite, which had been allowed to develop in ten-inch boiling tubes containing a short length of branch partly embedded in soil. These tube-colonies were derived by over-flow from a large one that had been established in the insectary (from the heavily infested stem of a young tree) in the hope that a substitute queen might be formed to maintain it indefinitely. This hope was encouraged when it was observed that winged adults had issued nearly four months after collection in the field; but it later appeared to have been groundless. Indeed when the colony was opened after more than a year in the insectary it was found to consist only of workers and soldiers, much depleted in numbers.

In the experiment carried out with the tube-colonies, the inocula were applied directly to the galleries that the termites had constructed in the short lengths of branch. In the case of one colony the inoculum took the form of a portion of a culture of *Conidiobolus villosus* on rice bran. With two other colonies, an aqueous suspension, made by shaking a bran culture of the fungus in sterile distilled water, was used instead. Appropriate controls were set up, these consisting of colonies treated in a like manner, but with the difference that the bran used in their case was sterile.

Whereas in both the colonies that had been inoculated with the aqueous suspension an infection developed which killed all the termites within 3 days, no sign of disease appeared in the colony that had been inoculated with the bran culture; the controls also remained healthy. Following on this result it was decided to make another attempt to induce infection in the field by using an aqueous suspension of a bran culture on a large scale. A heavily attacked tree whose stem had been hollowed out was chosen for the test. The contents of twenty tubes containing cultures of *Conidiobolus villosus* were suspended in water and then poured into the cavity through a hole cut with an axe. The tree was felled and examined a month later: There was no indication that the fungus had had any effect, termites still being present in vast numbers.

IX. Cockchafer

General Observations. The cockchafer pest has continued to remain of minor importance. A certain number of larvae were collected in Pahang in the course of a tour of estates which had suffered from cockchafer attacks before the war, and

further specimens were received from an estate in Kedah where replanting of a once heavily infested site was in progress. The only other source of material was a seedling nursery in Pahang where the grubs were present in negligible numbers. This site, incidentally, had been occupied by *Mimosa invisa* at the time when the eggs must have been laid. In all the areas mentioned species of *Leucopholis* predominated. *Psilopholis vestita* was nowhere encountered.

(1) BIOLOGICAL STUDIES

Observations on Leucopholis rorida. *Leucopholis* larvae that had been collected in the field during the latter part of 1947 were reared in the insectary. Those which became adult were found to be exclusively *L. rorida*. Kept in cages with soil and available food they failed to lay eggs. The cause of their infertility is thought to have been connected with the disturbance of their flying habits. Indeed, it was difficult to get them to fly at all, although they could sometimes be induced to do so by blowing on them. Some information was gained as to their food preferences. Accepted leaves, in descending order of choice, were Mango (*Mangifera* sp.); Rambutan (*Nephelium lappaceum*); and Wild Cherry (*Muntingia calabura*). Leaves of *Ficus fistulosa* and of a species of *Cassia* were not accepted. The question of the food preference of the adult is considered to be of importance, since it must clearly have a bearing on the distribution of the pest.

A parasite of Holotrichia bidentata. The Tachinid parasite bred from *Holotrichia bidentata*, which was mentioned in the previous annual report, has now been identified as *Eumyocera carinata* Towns.

(2) STUDIES CONCERNED WITH POPULATION TRENDS

Observations on the incidence in Pahang and Kedah. So long as cockchafers remain of little importance it is inevitable that the data relating to their incidence will be fragmentary, but even so they have a certain value.

All the evidence obtained during the tour in Pahang pointed to a marked decline in cockchafer population having taken place since the years immediately preceding the war. Even on properties where signs of the damage caused by this pest in the past were still visible, relatively few specimens were found.

A survey made in Kedah in connexion with a replanting experiment, which is described below, gave an estimate of 7,000 grubs to the acre—a figure that is probably not more than a tenth of that attained at the time when the pest reached its climax. Species of *Leucopholis*, and these mostly *L. rorida*, accounted for about 44 per cent. of this population.

(3) THE INVESTIGATION OF CONTROL MEASURES

Field trial of insecticides. An experiment, whose object was to test the protective value of three insecticidal dusts when these were mixed with the soil of the planting hole, was laid down on an estate in Kedah where a 14-acre field that had been severely infested by cockchafer in 1937 was being replanted. Before the decision was taken to use this site a survey had been made of its grub population. For this purpose the field had first been divided into quarter-acre plots, and then a detailed record was compiled of the distribution and identity of all grubs recovered during the excavation of the planting holes.

Although the incidence disclosed by this survey was not as high as could be desired, it was decided to proceed with the experiment as no alternative site was available. A square block consisting of sixteen $\frac{1}{4}$ -acre plots through which the cockchafer population was fairly evenly distributed was selected. The four treatments (5% D.D.T.; Agrocide 2; 5% Toxaphene; and an untreated control) were disposed in the form of a Latin Square. Each insecticide was applied at the rate of two ounces per point, being mixed with the soil of the planting hole at the time of planting. Before being employed in this trial the insecticides had been tested on potted seedlings to confirm that they exerted no phytotoxic effects. The experiment was still in progress when the year ended.

Light trap. An experimental light trap designed to work with a paraffin pressure lamp has been constructed. It is proposed to test this in the field early in 1949.

X. Mites

General Observations. Of the several species of mites that occur on rubber, *Hemitarsonemus latus*, the Yellow Tea Mite, is without question of the greatest significance as a pest. Not only is this acarid second in importance to *Oidium heveae* as a factor responsible for the annual epidemics of secondary

leaf fall, but it is also capable of inflicting severe damage on young seedlings and budgrafts. Data which throw light on the part which it takes in the causation of the former disease will be found in Table XVII.

The published work on the acarid fauna of rubber is not extensive, and there are still many gaps in our knowledge. To close these and so enable us to approach the difficult question of relationship between mites and leaf infecting fungi from firmer ground, the life histories and habits of the various species are now being investigated.

(1) BIOLOGICAL STUDIES

Observations on Hemitarsonemus latus. It has been found that *Hemitarsonemus latus* can be reared easily in the laboratory by culture on detached leaves. The young leaflets employed in this method are laid with the lower surface uppermost on pads of cotton wool—or on several thickness of blotting paper cut to a suitable size—which are kept moist by being retained in open dishes containing a small quantity of water. Provided a leaflet is not allowed to carry more than a few mites it will stay fresh for two or three days. Only very young leaflets are used, for although older ones will last longer they are not acceptable to *H. latus*; which, since the mite only occurs in nature on immature organs, is what might be expected. With the aid of this technique it has been possible to acquire much information on the life history and habits of the species. A brief summary of the observations that have been made follows immediately below.

In the laboratory, with air temperatures ranging between 24°C. and 30°C., the duration of the egg stage is about 40 hours; that of the larval stage 25 to 30 hours. Males complete their development a little faster than the females. It is characteristic of the family Tarsonemidae that the larvae become adult without an intermediate instar. The larvae of *H. latus*, however, enter a quiescent stage immediately before becoming adult, and it is then that the immature females are carried by the adult males, held on a dorso-posterior sucker. Fertilisation of these females takes place immediately upon their shedding the larval skin, and oviposition begins within a further 24 hours. Egg production by isolated females was very variable in our observations, with a maximum of 12 and an average of about 8 each day. Considering the fact that the egg is half as long as the female's body, this rate of egg production is remarkably high. The maximum fertility

observed was a case of a female which laid 58 eggs in seven days.

The sex ratio of *H. latus* is inconstant, because of the fact—first recorded by Gadd*, and which we have since confirmed—that unfertilised females give rise only to males in the next generation. The offspring of fertilised females include both sexes, but females outnumber the males by about four to one.

Observations on a mite predatory on Hemitarsonemus latus. During the course of the work on *H. latus* it was frequently seen to be attacked by a predatory mite. This predator, which is provisionally regarded as a species of *Typhlodromus* (Laelaptidae), has also been successfully bred in the laboratory. It was so voracious, however, that only small numbers could be maintained, since readily available supplies of its prey were limited—these being derived from artificially infested seedlings.

Observations on the life history of the Laelaptid made at a controlled temperature showed that the life cycle required a minimum of seven days at $25^{\circ} \pm 2^{\circ}\text{C.}$, the durations of the various stages being roughly as follows: the egg stage two days; the larva, protonymph and deutonymph each about one day. The adult female required a further two days before egg-laying began. Unfertilised females laid no eggs. The daily rate of egg production was determined mostly by the availability of food, the maximum in the presence of abundant food being four eggs. The normal duration of adult life was not accurately estimated, because many mites escaped from the leaves and were drowned. One female, however, was maintained for 29 days from the time of emergence until death, and laid 37 eggs.

All stages of the predator showed a preference for the eggs of *H. latus*, and larvae were preferred to adults; the larval predators in particular found difficulty in overcoming adult *H. latus*. Some figures were obtained of numbers of the pest destroyed by different stages of the predator. One pair (adult male and female) killed 35 adults and 294 eggs in four days. An isolated female, which was not laying eggs, killed 153 adults, 49 larvae and 319 eggs in nine days, having been supplied mostly with adult *H. latus*. Six predators, supplied with eggs only, consumed an average of 49, 48 and 47 eggs each as larvae, protonymphs, and deutonymphs.

* Gadd, C. H., *Bull. Ent. Res.* 1946, 37(2), 157-162

Comparison of the Laelaptid mite with the illustration of the so-called "Grey Mite" in Steinmann's book on the diseases and pests of rubber in the Netherlands Indies† showed a close affinity between the two. It seems probable that the "Grey Mite" was not, as it was described, a pest of rubber but in reality a predator. Its presence on deformed leaves was presumably due to its pursuit of the pest actually responsible for causing the deformity.

Other Observations. Tetranychid mites (red spiders) have been found on rubber seedlings, most commonly on fully expanded leaves. Detailed studies have not yet been made.

An unidentified thrips has been observed to be predacious on *Hemitarsonemus latus*.

XI. Other Insect Pests

THYSANOPTERA. Our interest in thrips on rubber was stimulated by finding the predacious species referred to above. In 1935 Beeley‡ had described a new pest of rubber which he called the "Hevea Thrips." During the war R. Takahashi* identified a thrips on rubber as *Scirtothrips dorsalis* Hood, which is a pest of chillies in India but had not previously been recorded in Malaya. Specimens of a leaf-feeding thrips found on rubber, presumably the same as the "Hevea Thrips", have been compared with the original description of *S. dorsalis* and found to agree. The predacious species, although bearing a superficial resemblance in the nymphal stages, is quite distinct. It has been found to attack *S. dorsalis* in addition to *H. latus*.

The eggs of *S. dorsalis* are laid in the plant tissue. On leaves of *Hevea* they are generally found singly along the veins on the lower leaf surface. The newly hatched nymph emerges through a small circular hole, and is quite colourless at first. By the end of the first nymphal instar it has become yellow, and by the end of the second instar almost orange. There follows a brief prepupal stage, in which the wing buds are short, then the pupal stage proper with well developed wing buds. The adult body is banded yellow and light brown, with darker wings.

† Steinmann, A., *Diseases and Pests of Hevea brasiliensis in the Netherlands Indies*, Buitenzorg, 1927.

‡ Beeley, F., *J. Rubb. Res.Inst. Malaya* 1935, 6, 58-61

* Manuscript note.

As reference to Table XVII will show, *Scirtothrips dorsalis* is occasionally found associated with cases of secondary leaf fall. To what extent it is responsible for the defoliation characteristic of this disease is not yet known.

COLEOPTERA. The flea beetle recorded last year as causing extensive defoliation of the fern *Nephrolepis biserrata* (an indigenous cover plant) on an estate in Pahang, has been described as a new species of *Eucycla* under the name *biplagiata*†.

Hypomeces squamosus, a common weevil which feeds on a great variety of plants, was found on two occasions during the year to have been the cause of damage reported in seedling nurseries.

Several cases have been encountered where rubber has been attacked by the bark beetle *Amphicrossus oblongus*, and by beetles of the genera *Xyleborus* (Scolytidae) and *Xylothrips* (Bostrichidae). In every instance examination revealed that the trees had been predisposed to these attacks by some prior injury.

LEPIDOPTERA. A caterpillar feeding on bark of a rubber tree was identified as *Cyana ridleyi*, an Arctiid moth which is already known to have this habit.

HEMIPTERA. Reports of outbreaks of mealy bugs and scale insects in nurseries were confined to the first half of the year. Whether this fact has any significance is not known. Among the species concerned were *Saissetia nigra*, *Ferrisia virgata* and *Pinnaspis aspidistrae*.

XII. Nematodes

No enquiry about eel-worms has been received during the year, and no work done under this section. It is expected that these pests of cover crops will become more important as replanting proceeds.

XIII. Other Animal Pests

Snails collected from tapping panels, where they were reported to be drinking latex, were identified as a species of *Amphidromus**. They were not present in sufficient numbers to constitute a pest.

† Brayant, G. E. *Ann. Mag. Nat. Hist.* 1947, 14(116), 587-588.

* We are indebted to Mr. M. W. F. Tweedie, Director, Raffles Museum, Singapore, for this identification.

Experiments on slug and snail baits. Slug and snail baits made with rice bran and powdered Meta fuel (metaldehyde) are very effective, but suffer from the disadvantage that they are rapidly washed away by rain unless protected in some manner, and to provide protection is hardly practicable on a large scale. Brick baits containing cement, with lime as the attractant and calcium arsenate as the poison, last for an indefinite period; they are not however effective against slugs, nor against snails in regions where lime is naturally abundant. It would clearly be advantageous to combine the attractiveness of the meta-bran baits with the permanence of the lime and cement baits, and experiments have been conducted with this object in view.

At first, lime and cement bricks were made containing Meta; these were very strong, but not sufficiently attractive. It was found, however, that they could be so constructed as to include rice bran, and were then attractive to both snails and slugs. Various mixtures were prepared, and small scale trials carried out to find the most suitable proportions of the four ingredients. Records of the number of slugs and snails caught showed that within fairly wide limits composition was not very critical; in general bricks containing a high bran content were more attractive, and those with a high cement content more durable. A good compromise was found to be (in parts by weight): Meta 1, lime 2, bran 6 and cement 6. Further tests indicated that satisfactory bricks could be made in which a proportion of the bran was replaced by rice husk, which is a much cheaper material. The best mixture of this kind seemed to be: Meta 1, lime 2, rice husk 3, bran 4 and cement 5.

XIV. Insecticides

Outbreaks of insect pests in rubber cultivations are sporadic and rarely extensive, and for this reason the opportunity of carrying out field trials of insecticides does not often arise. Nevertheless, some small scale tests were made during the year of which two (whose object was to determine the phytotoxicity of the preparations) are worthy of brief mention.

Lead arsenate and lime. The addition of slaked lime to a lead arsenate spray appears to improve its tenacity; but since rubber has been reported to be intolerant of lime it was important to find out how much could be incorporated with safety. Accordingly six-months-old seedlings were sprayed with 1% lead arsenate containing various admixtures of slaked

lime ranging from 0.1% to 2.0%. No injury was discernible even with the highest concentration.

D-D soil fumigant. A soil injector was used to apply D-D soil fumigant in a nursery of five-months-old seedlings growing in a light loamy soil. The rows of seedlings were three feet apart, and between these the injection points were spaced at one-foot intervals in two lines, each one foot from the seedlings. The quantity injected at each point (in separate plots for each quantity) was 3 cc., 5cc., 7cc., 14 cc., and 28 cc. The hole made by the injector was closed after each injection by treading in the soil. With dosages up to 5 cc. the seedlings suffered no permanent injury, although some were defoliated; at concentrations beyond this severe damage resulted. The 5 cc. dosage is comparable with that recommended by the manufacturers for the control of soil pests, but, owing to the high toxicity of D-D, *only* for use on fallow land. In these circumstances it is surprising to find that rubber can survive such treatment, at least on some soil types.

XV. Root Nodule Bacteria

General Observations. A few requests for cultures of *Rhizobium* for the inoculation of leguminous cover crop seeds were received during 1948.

Laboratory studies. The *Centrosema* isolations referred to in the previous annual report were re-tested by passage through the plant and one which was found to have declined considerably in nitrogen-fixing ability was discarded. Two strains of *Rhizobium* that had been isolated from the nodules of *Pueraria javanica* were in the course of being tested at the end of the year. Some observations have been made on nodulation in *Flemingia congesta*, an indigenous leguminous shrub whose potentialities as a cover crop are being investigated by the Botanical Division. Plants of this species raised in pots on sterilized sand watered with a nitrogen-free nutrient solution were inoculated soon after germination: (a) with a strain of *Rhizobium* isolated from its own nodules, and (b) from the nodules of *Centrosema pubescens*. Uninoculated controls were set up. The inoculated plants grew slowly but had a healthy appearance. The controls were very weak and sickly. The plants were lifted when four months old, and, after inspection, passed to the Soils Division for determination of dry weight and total nitrogen. The results of this experiment are tabulated below.

TABLE XX. *Effect of two strains of Rhizobium on nitrogen-fixation in Flemingia congesta*

Inoculum	No. of plants	Nodules per plant	Mean dry weight	Mean nitrogen
Flemingia strain F.4 ..	5*	19.6	gm 0.517	mgm 11.0
Centrosema strain C.6 ..	4	15.0	0.233	6.8
Uninoculated ..	3	nil	0.038	1.1

* One of the controls was inoculated with F.4 in error.

Advisory Work

Summary of advisory activities. The number of letters despatched from the Division during the year increased slightly to 676. Specimens sent in for examination, about half of which were in connexion with the annual survey of secondary leaf fall, reached a total of 340. The graduate staff of the Division paid 95 visits to estates and smallholdings, and 96 visits to the Experiment Station. Interviews at the Institute numbered 101.

Circulars and leaflets. The following circulars and leaflets were issued during 1948:—

P/AL. 2(48). Mouldy Rot

P/AL. 3(48). Mites

P/IN. 1(48). Fungicides approved for use in the treatment of Mouldy Rot.

R. A. ALTSON,
Head of Pathological Division

KUALA LUMPUR
17th November, 1949

REPORT FOR THE PERIOD SEPTEMBER 1945 TO DECEMBER 1948

CHEMICAL DIVISION

SEPTEMBER 1945-DECEMBER, 1946

STAFF

Before leaving for the United Kingdom after liberation from internment the Director, Mr. Page, returned to Kuala Lumpur and completed arrangements for the Institute to resume its activities under the temporary control of the British Military Administration. Mr. Sekar continued in charge of the Chemical Division until the writer returned to Kuala Lumpur at the end of February 1946 to take over as Acting Head of the Division. He then left to take long leave in India and returned to duty in October.

Mr. W. S. Davey, the Head of the Division, was known to have been on board a boat which left Singapore just before the capitulation. This boat was bombed and sunk by the Japanese. After so long a period without further news it must be assumed that he lost his life. The Institute and the Chemical Division lost in him an able leader, and his colleagues and staff a loyal friend who is sadly missed. Mr. V. H. Wentworth was a prisoner-of-war in Singapore and after his arrival in England on recuperation leave decided not to return to Malaya. Mr. J. H. Pidford, the Chemical Engineer, was also made a prisoner-of-war. After recuperation leave he returned to duty in May. Both he and the writer have been on duty for the remaining portion of the year.

The first impression received was that the Division had not suffered such serious losses as were expected. Whilst this is generally true it was soon evident that much was missing in both records and apparatus. A good deal of the latter was superficially complete, but examination showed that parts were either broken or lost. During the period between the Japanese capitulation and the time when the B.M.A. took over, there was a second wave of looting and general disorder. There is moreover, little doubt that had it not been for the efforts of the junior staff, who did their utmost to protect and restore the Division, the losses would have been much worse.

Most of the laboratory assistants who had been employed by the Japanese or who had left the Institute for various reasons during the occupation, returned to duty by the end of March. Nearly all were much overdue for long leave and for the rest of the year continual changes were taking place as it became possible to obtain passages for them to their home countries and allow them to take their leave. It was particularly sad to hear just before my return of the death of Mr. Masillamoney, one of the oldest and most senior members of the Division. He had been responsible for the work in the experimental vulcanising section of the Division for many years and I should like to pay tribute to the good work which he did for so long.

Later in the year several assistants resigned and secured work elsewhere on better terms. Owing to the lack of the equipment which these assistants would normally use this has not affected the work of the Division as seriously as it would have done under normal conditions, but it will be necessary to recruit and train a new staff before the work can be resumed.

This lack of equipment and shortage of staff has greatly restricted the amount of research work which could be undertaken and most of the work done has been concerned with administration and reconstruction. The amount of advisory work, however, increased steadily throughout the year as more estates were reopened and brought into production.

Research

LATEX

Our colleagues of the London Advisory Committee for Rubber Research have developed methods for the determination of water soluble and insoluble acids in preserved latex which are thought likely to be of considerable value in its evaluation and suitable for routine control tests. Experiments with their technique were commenced and it is hoped to study the properties of clonal latex over a long period as soon as suitable arrangements can be made to obtain a regular supply.

From the information available to us in London before our return to Malaya, it was evident that there would be an increase in the preparation and export of latex. Consumption was expected to amount to three or four times that of before the war as soon as the latex could be produced. The only publications of assistance to the producer were much out of

date and a new advisory manual was badly needed. Mr. Pidford accordingly began a review of the literature and available records to secure an up-to-date foundation on which we could base our advisory work and plan our future research. It was clear that the patent situation in Malaya was not satisfactory and this aspect was also investigated. Good progress was made and at the end of the year the first draft of a new Planting Manual was ready. By this time it was evident from the volume of inquiries concerning latex which were being dealt with that the publication would be of great value to the producer; particularly to those to whom latex production was quite new. Some experimental work was carried out to obtain information on what losses in ammonia might be incurred in the field with various strengths of solutions. The results were needed for the publication since, together with other data of a similar nature, no records now remain in the files.

Towards the end of the year there was a considerable demand for the export of preserved field latex of 38-40 per cent. d.r.c. Many estates were anxious to prepare this and sought our assistance in making surveys of the suitability of their latex. Of the numerous samples tested in the laboratory very few were found to reach a d.r.c. of 38 per cent. Appreciable acreages of young budded rubber were then coming into tapping for the first time, and after the first few tappings a lower d.r.c. than is suitable for export as preserved field latex was general.

CONCENTRATION BY CREAMING

Samples of a new sodium pectate were received. They were said to be very good creaming agents, but exhaustive tests made at various levels of ammonia preservation did not confirm the claims made. The pectate could not be recommended as a satisfactory creaming agent.

Creaming experiments were carried out with aqueous extracts prepared from some of the local plants. One of these was particularly promising and might have been worth further study if it had not been found subsequently that similar work had already been carried out in Java. The conclusions reached there were very similar to our own.

A technique to reduce to a minimum the plant and chemicals required for creaming on a commercial scale was tested on a laboratory scale. The method was thought to be suitable for easy estate operation and good results were

obtained with average latex. A small pilot plant was then constructed at the Experiment Station at Sungei Buloh to test the method on a larger scale. A few experimental runs were made with rather variable results. The latex used was not taken from a bulk, representative of the whole crop from the commercially-tapped area on the estate. Poor creaming results were found to result from the use of certain latices, usually of low d.r.c. or from very young rubber. It was evident at the end of the year that a close study of the practical considerations involved in estate creaming was desirable and Mr. Pidford was devoting as much time as possible to this.

CENTRIFUGAL CONCENTRATION

No work was carried out on this subject. The Westphalia machine in the Division received very bad treatment during the occupation. It was removed by the Japanese and used for work with caustic soda and rubber seed oil, tars and resins. The motor in common with many others was later stolen and much work will be required to put the machine in order.

PREPARATION OF SPECIAL AND MODIFIED RUBBERS

In 1945 a conference of representatives of rubber manufacturers and trade organisations in Great Britain was called to formulate recommendations which would enable growers to prepare and pack the bulk of their product in the form and quality most suitable for use by manufacturers. The report of this conference indicated that although smoked sheet was thought likely to be the main product for the time being, a demand was expected for new types of rubber for special purposes which in some cases might become large.

Mention has been made in this and earlier reports of the work carried out at the Institute concerning the production of soft rubber by the producer. It is believed that the commercial preparation of such rubber which was beginning to expand immediately prior to the war, will be undertaken again by the organisation which was interested as soon as the estates can be set in order and the necessary materials obtained.

As a result of the work carried out in America during the war in the synthetic rubber industry, many new types of plasticiser were evolved. Some of these may be of value for incorporation into latex prior to coagulation, and samples have been requested for evaluation. Any reduction in costs

of preparation which can be made will obviously be of the greatest assistance in furthering the expansion of this form of special rubber.

A new method for the preparation of dry rubber which involves a flocculation process was described during the war years and patented. Some preliminary experiments were carried out to investigate this method. The results suggested that there was little promise of it proving satisfactory on a commercial scale. The latex would need to be pretreated with a chemical and aged for a day or two before flocculation would occur.

The incorporation of carbon black into latex by the producer prior to coagulation, machining and drying is an obvious possibility arising from the work on the addition of softening agents. It has already been successfully carried out with synthetic rubber. Following the polymerisation process the black is incorporated and the mixture coagulated and dried, usually as a crumb. Work was started on this subject with a view to development to a stage whereby carbon black sheet could be made. Only small supplies of gas black were available and these, which had been prepared by the Japanese during the occupation, were of very inferior quality. Owing to our inability to obtain the other chemicals and apparatus required only preliminary work could be carried out. It indicated, however, that the addition of the black to the latex as a dispersion caused a marked softening of the dry sheet prepared. With the incorporation of amounts up to approximately 30 per cent. softening was progressive, but beyond this amount hardening was observed and the sheets were extremely tough and stiff. At the end of the year a few samples of different types of black had been received and the work continues. It is evident that there are a number of practical problems, concerned with the type of black and its incorporation which will need considerable study before carbon black rubber sheet of controlled quality can be satisfactorily offered by the producer. Further study of these considerations will depend very largely on the staff and time available.

Some interest is shown by American consumers in a pale sheet as a substitute for crepe in the manufacture of tyres with white side walls. This revives interest in hot-air-dried sheet which may be of value for this purpose. Some experiments were made using various amounts of bisulphite to improve the colour of hot-air-dried sheet which is usually slightly yellow. Compounded stock made from such sheet did

not show any improvement after vulcanisation over the normal hot-air-dried controls. The demand is likely to be governed by the ageing properties of the rubber and to test its suitability trials are needed by the consumer.

TECHNOLOGICAL STUDIES OF RUBBER

The vulcanising and testing equipment suffered badly after the British evacuation. Apparatus belonging to a local company which maintained a testing laboratory before the war had been brought to the Institute by the Japanese as replacements. This had to be returned to the company and as a consequence the resumption of all work of this nature must await the delivery of new apparatus.

Plasticity determinations with a Williams plastometer were started on rubber prepared from individual tree collections in some of the plots containing the most promising of the R.R.I. 500-series of clones. The results indicate that in R.R.I. 501 we have a rubber which is much softer than average. The work of our London colleagues indicates that considerable differences in plasticity between rubbers, which was hoped might be due to difference in molecular structure and therefore possibly result in differences in other physical properties, does not appear to give important differences when compounded in tyre tread mixes. The clone R.R.I. 501 is likely to be extensively planted in the future, and the soft rubber characteristic may be of importance in breeding for quality.

ESTATE TECHNIQUE

Smoke-house accommodation at the Experiment Station had become insufficient to deal with the crop harvested, and a new smoke-house of greater capacity was sanctioned. Opportunity was taken to incorporate into this some modifications of our present recommendations for the Tunnel type. Mr. Pidford has designed a larger house which was under construction at the end of the year.

Following the recommendations made in the Conference Report to which reference has been made earlier, experimental work was undertaken in connection with the packing of a smaller bale. The request for this work arose from the war-time handling of synthetic GR-S which was packed in 75-lb. containers of brick shape. The manufacturers found less distortion, greater ease of handling and stacking, quicker thawing out, better blending and manipulation. It was pointed out when the subject was discussed in London before our

return to Malaya, that the preparation of a smaller bale would entail increased expenditure by the producer, and that he could not be expected to adopt any new packing of this nature unless a premium were offered. It was agreed that an experimental shipment of 20 tons should be made to obtain the consumers' views. A method of packing and marking 75-lb. bare-back bales of dimensions 28 inches by 14 inches by 8 inches was worked out using the simplest equipment possible and a consignment of 20 tons was prepared at the Experiment Station. This was sent to the United Kingdom just before the end of the year. The experiment showed that the cost of packing a small bale would be nearly twice as much per pound of rubber as for the present 224-lb. bale. No further action in this matter is contemplated until the report on the shipment has been received.

Advisory

A feature of the advisory work was the initial uncertainty of the producer in deciding what form of rubber to prepare. Faced with the problem of complete renewal of their equipment, producers hesitated to erect factories and smoke-houses of a permanent nature. Many were considering the production of latex or sole crepe, and there was a strong tendency to erect temporary or semi-permanent smoke-houses which would enable them, with the aid of reconditioned batteries, to undertake immediate production of smoked sheet pending further decisions. Towards the end of the year, however, inquiries concerning sheet manufacture were for new factory layouts with smoke-houses of a more permanent construction.

Since plywood chests were unobtainable almost all the rubber shipped during the year has been packed in the form of bare-back bales. There have been serious complaints of massing, distortion and illegibility of marks. Steps were taken to impress upon the producer that unless packing was improved, the shippers and dealers might refuse bare-back bales and insist on some alternative packing. An advisory leaflet on methods of packing, using simple equipment easily available, was prepared and distributed to inquirers. As more experience was obtained by the producers the quality of bare-back bales improved, and, in general, those produced on estates were much better than those packed in godowns by rubber dealers. Owing to fire hazards, a heavy insurance premium was demanded if the bale paint used to coat the outer wrapping was made with either petrol or kerosene. No satisfactory

quick-drying alternative was found but of a number of pastes tried, a mixture consisting of a suspension of talc in a starch flour solution was found to give a good coating. Drying is slow but this is of no great importance on estates, where the number of bales produced daily is low and there is ample space. It is, however, a more serious matter for the godown packer.

The shortage of coagulants was for a long while acute and a large black market sprang up. The amounts of acetic and formic acids coming forward were not adequate to deal with production, and sulphuric acid, fermented toddy and other coagulants were used. The shortage of acetic and formic acids persisted until the end of the year but increased quantities of sulphuric acid became available. It is evident that a large amount of rubber exported during the year has been coagulated with this acid, and that much of it coming from the small-holder has not been produced with the careful attention that is necessary if sulphuric acid is used.

A circular No. 16, "Preparation of Coagulant from Coconut Toddy" was issued early in February. This was a revised edition of one produced during the occupation.

There was much correspondence dealing with estate chemicals and instruments for testing the d.r.c. of latex, such as metrolacs, simplexometers and latexometers. Many of these instruments were very old and in bad condition. Normally no attempt would have been made to repair them and the purchase of new ones would have been advised. Since new ones were not available much time has been spent repairing and making the old ones serviceable.

Analysis of the correspondence of the Division shows that 939 letters were received and 995 despatched, most of these being in the second half of the year as the advisory work increased. A total of 419 samples were examined and the number of visits paid was 62. The year was generally one of extreme difficulty with considerable unsettlement inevitable as an aftermath of the occupation.

II. REPORT FOR THE YEAR 1947

The work of the Chemical Division continued to be severely handicapped by shortage of staff. With the resignation in November of Mr. Pidford, the Chemical Engineer, the strength of the Division was reduced to one senior officer and Mr. Sekar, the Assistant Chemist. Much time was devoted to

the restoration of the Division and to advisory work which increased steadily as more estates were brought into production. By the end of the year sufficient apparatus and stock of chemicals had been acquired for a programme of research to be undertaken, but for the reason given above little work of this nature could be done.

CHEMISTRY AND TECHNOLOGY OF LATEX

A small area, near the Institute, containing a few young buddings of some of the more important clones, was brought into tapping for the first time early in the year by the Smallholders Advisory Service. The opportunity was taken to carry out a series of investigations on the properties of the mixed clonal latex using an extraction technique which has been developed in the London Advisory Committee's laboratory for the determination of total acidity, ether-soluble, water-soluble and combined acids on dried latex films. The determinations were made on the fresh latex shortly after tapping, immediately after ammoniation, and after storage of the preserved latex for fifty days. It was found that when ammonia is added to fresh latex there is an immediate fall in the acid value followed by an increase; the amount of combined acids is not much affected at first, but falls on prolonged storage of the latex. The values for the water-soluble acids increased on storage and big differences were found between the values for different tappings. It has been suggested that the formation of these water-soluble acids is due to the combined effect of ammonia and biological agencies, and that early ammoniation and destruction of bacteria are important in reducing the amount produced. The variations found from day to day indicate that control by early ammoniation is not very effective. It is also suggested that there may be a correlation between the stability of the latex and the amount of the water-soluble acids present. A medium speed stirring apparatus originally developed in London and used for earlier work on testing stability was available and parallel tests were carried out with this apparatus. In this test the latex is stirred in the presence of zinc oxide and stability is found to increase as the latex ages. No correlation was apparent between the results and either combined or water-soluble acidity. The stability test is, however, now regarded with some suspicion and the results obtained cannot be considered at all conclusive. It is evident that the development of a more suitable measure of stability is required and

this subject will be fully investigated as soon as the staff position permits. From the results of some similar extraction experiments on films from individual clonal latices indications were obtained that differences are to be expected amongst clones. The figures obtained for the amount of combined acids present are both appreciably higher and lower than those observed with the mixed clonal latex so far examined. The experiments are to be extended to cover a study of clones from another source.

LATEX PRESERVATION AND CONCENTRATION

Preservation

Owing to the shortage of ammonia some interest was shown by Americans in the possibility of preserving latex with monoethylamine and late in the year supplies of this chemical were received for trial. Owing to its inflammable nature the hazards of shipping monoethylamine and latex preserved with it are of some concern. Experiments so far carried out have indicated that quantities greater than 0.2 per cent. on the latex are still effective as preservatives after a period of just over two months. A bad smell develops, however, and with increasing amounts of monoethylamine this rapidly becomes worse; with amounts above 0.5 per cent. it is particularly objectionable and it is doubtful if the consumer would consider the latex suitable. Samples have been sent to America but the trials have not yet been in progress long enough to justify further comment. Similar experiments with di-ethylamine, of which a small quantity was available, have given satisfactory preservation over a period of seven months when used at a concentration of 0.5 per cent. and more on the latex.

Several new fungicides have been tested during the year as preservatives. When added by themselves they have generally been found unsuitable at all concentrations. In the presence of small quantities of ammonia, however, some promising results have been obtained with an American proprietary material which is understood to be mainly zinc dimethyldithiocarbamate. When added together with 0.1 per cent. ammonia, 0.1 per cent. of this fungicide is enough to give adequate preservation over a period of four months. This is the first time that we have found so small an amount of any chemical to preserve latex satisfactorily for so long a period in the presence of only 0.1 per cent. ammonia. The results have prompted an investigation with small quantities

of other accelerators of a similar composition. Most of them have been found unsatisfactory but a few are promising, although they do not appear to be so outstandingly good as zinc dimethyldithiocarbamate. This work is to be continued to determine whether modifications of the composition can be made to retain the preserving power without the accelerating activity of the added compounds.

Latex Concentration

The export of rubber from Malaya in the form of latex of all types reached the record quantity of over 27,000 tons in 1947. A very large volume of advisory work is concerned with producers' inquiries into the prospects and possibilities of latex concentration. The second edition of Planting Manual No. 4 "Latex Preparation, Concentration and Shipment", revised and rewritten by Mr. Pidford, was published at the beginning of the year. This gives the producer a comprehensive account of the present position concerning latex, and has been of considerable assistance to those who are either new to the work, or considering a change to its production.

Until quite recently producers of latex were unable to obtain laboratory apparatus, and we have undertaken a considerable volume of testing work on their behalf. Assistance has been given in many latex surveys from different areas and types of rubber. An advisory leaflet was issued giving the minimum requirements of apparatus needed for such work on estates. Orders placed by importers a long time ago are now being delivered and the supply position is easier. The Institute has given instruction and training in the methods of latex testing to producers' staff. Over twenty trainees were received in the laboratory during the latter portion of the year.

Creaming

Centrifugal concentration has attracted much attention but owing to the delay in the delivery of centrifugal machines, which still takes from eighteen months to two years, producers have been interested in the immediate production of creamed concentrate. At the end of the year several large creaming plants had been erected and had either commenced or were about to commence production. These producers of concentrated latex are purchasing latex from various estates, sometimes from widely scattered areas, and conveying it to the central factory by lorry tanker for processing. In

addition a number of individual estates have plants under construction. Most of the large-scale producers have also erected port bulking installations, thereby avoiding the heavy packing charges now incurred by the smaller producer owing to the very high price of drums.

Laboratory creaming experiments have been continued in order to obtain data on the many points on which more information is needed. It is evident that a complete investigation of the variability of latex as shown in the creaming process is a large undertaking, and one that will take much time. The object of the work which has so far been carried out has been to provide indications which will be of assistance in guiding us in the immediate advisory work. There is evidence of characteristic differences between clonal latices, but day-to-day and plot-to-plot variations between trials of the same clone may be as great or greater. The evidence now available shows that there is no reason to suppose that latex from mature trees of high-yielding clones will be unsuitable for the production of cream concentrate. Possible variations in the properties of the cream from different clones has not yet been studied and must be undertaken as soon as possible. There is in general a very strong correlation between the field dry rubber content and the d.r.c. of the concentrate produced therefrom by normal creaming. With young rubber of low d.r.c. of both seedling and clonal origin, it is sometimes very difficult to produce a cream of 58-60 per cent. d.r.c. by straight creaming. Mr. Pidford has, however, found no evidence of behaviour which conflicts with the recommendations made in the Planting Manual. From the results of experiments made on various means of improving creaming, it seems probable that all latices can be creamed to give a 58-60 per cent. concentrate by proper selection of creaming agent and process. Some particularly interesting experiments on the removal of sludge prior to the addition of the creaming agent have indicated great improvement in creaming, especially with latex from young rubber with a low d.r.c. In these experiments sludge settlement has been accelerated by centrifugal force in a laboratory centrifuge immediately after ammoniation of the latex. The results suggest that the cleaning of the latex by means of a clarifier, prior to the creaming process, would be of great benefit. At the end of the year an account of these preliminary experiments was being prepared for publication.

Work on the evaluation of new creaming agents has continued whenever such have been received. In this connec-

tion an unpublished paper by Mr. W. S. Davey, the late Head of the Division, and Mr. Sekar, "The Evaluation of Creaming Agent", was presented at the Manchester Latex Conference, organised and held by the Institution of the Rubber Industry in June 1947. It has subsequently been published as Communication No. 264 in the Journal of the Institute.

Ammonium alginate appears to be generally preferred by the consumer, particularly by American interests, to sodium alginate as a creaming agent. Tests made with a special type of ammonium alginate of American origin have shown that it is superior to anything now procurable from sterling sources. British manufacturers are however engaged on this problem. The products so far offered as substitutes for the American alginate and sent out for test have not been satisfactory, but it is hoped that an equivalent will shortly be available.

Centrifugal Concentration

It is believed that almost all the pre-war producers of this type of concentrate are now again in full production. A number of others preparing cream will change to centrifuging as soon as the machines they have on order are delivered. The question of the unsuitability of latex from clone Glenshiel 1 has been raised. Some experiments have been carried out in collaboration with an estate particularly interested, to ascertain if a proportion of G.1 latex can be included. The indications were that the addition of up to 10 per cent. of this latex did not appear to cause the difficulties in concentration which have been previously reported when it is centrifuged by itself. Samples of the concentrate prepared from such mixtures have been sent to our London colleagues for a more complete examination of their physical properties than we are at the moment able to carry out. It is not yet possible to offer further advice on this matter.

PREPARATION OF SPECIAL AND MODIFIED RUBBERS

Some work has been done on the incorporation into the latex prior to coagulation and manufacture, of a new peptiser, Pepton 22, developed in America. This was made available to us by courtesy of the American Cyanamid Corporation, the makers. It is stated that the inclusion of small amounts will not noticeably affect the plasticity of the rubber, but its breakdown on the mill will nevertheless be much easier. Our experiments did not altogether confirm the claims, but we did not at first appreciate that hot mastication is

essential and that there is a critical temperature below which the peptiser does not work. Our facilities for hot milling have not permitted us to masticate at this temperature. A rubber which is easier processing, yet does not show any softening during preparation, has advantage over the usual form of softened rubber for packing in the bare-back bales now commonly used. It may, however, be of more limited use as a softener for incorporation during preparation because high temperature Banbury breakdown is needed to secure the softening effect.

Little progress has been possible in the investigation on the incorporation of carbon black during the preparation of sheet. There are difficulties to be overcome when the pelletised form of black is used, particularly in the preparation of the dispersion or slurry which must be made. Some rather variable results have been obtained in connection with the period of ball milling given to the black. It is thought that the manufacture of this type of rubber and development to the stage of estate practice will not be quite so straightforward as it at first appeared. The furtherance of the work must necessarily be delayed until more staff is available and the time can be given to it.

Our London colleagues have evolved a laboratory apparatus for the continuous coagulation of latex in the form of a very thin film. Their work was necessarily carried out with preserved latex but the results justified the belief that the process could be used with fresh latex, and the apparatus was sent out to the Institute for experiment. Such work as has been possible has shown, as was expected from the difference between preserved and fresh latex, that there are a number of important problems to be solved before such a method of manufacture can be adopted. One of the most important of these is concerned with the period during which latex can be kept in a suitable condition to coagulate satisfactorily in the apparatus. Fresh latex will not normally remain in good condition for more than a few hours without the addition of a preservative and its coagulation is then more difficult. Experiments have therefore been carried out to find a method of preserving and at the same time sensitising the latex, so that it is possible to obtain satisfactory coagulation over a period of twenty-four hours. Some promising results were obtained. By the addition of suitable amounts of formalin and a coconut oil soap, a method of running such a plant continuously should be possible. A larger plant is now under construction in the London laboratories which should

provide information on the drying of the film produced. This should indicate the lines on which work should proceed here when this is possible.

TECHNOLOGICAL STUDIES

The long and unavoidable delay in getting new equipment or replacements for the damaged or missing parts of some of the surviving apparatus has prevented the undertaking of nearly all work of this nature. Towards the end of the year sufficient equipment had arrived for vulcanising work to begin. Unfortunately there was insufficient time to train the new staff in this section of the Division and it was found possible to undertake only preliminary work on testing carbon black mixes of a tyre tread type.

Replacements for the missing parts of the Mooney plastometer were received and the instrument is now working satisfactorily. Routine parallel tests with the Williams instrument are being carried out on clonal rubbers, and confirm that there does not appear to be any change in the relative plasticities of rubber from the trees of certain clones found to be abnormally hard or soft some years ago.

ESTATE TECHNIQUE AND ADVISORY WORK

In addition to the interest shown in latex production, much advice has been sought on plans and designs for smoke-houses and factory installations. The larger modified Tunnel type of smoke-house erected on the Experiment Station has continued to work satisfactorily, although some difficulty was at first experienced in drying in four days; this could be attributed mainly to the uneven thickness of the sheet coagulated in tanks in need of reconditioning. Satisfactory reports on this type of smoke-house have been received from other sources.

Smoked sheet is now almost entirely packed and exported in bare-back bales. A circular No. 24, "Bale Packing of Rubber", was issued, calling attention to the need for care in preparing such bales. Many requests for an advisory leaflet describing packing methods were received from producers, and it is thought that most estate rubber is now fairly well packed. Towards the end of the year, however, complaints were received concerning the illegibility of the bale markings and the gritty nature of some of the materials used for painting. Formerly a suspension of talc in petrol or kerosene thickened with rubber to form a paint was used, but owing to the risk of fire and the consequent heavy insurance premium required,

this has generally been replaced by a starch paste containing talc in suspension. It has been suggested that the starch paste may perhaps be responsible for the caking of the talc into small, hard gritty lumps. Work is proceeding on the subject to ascertain what improvements may be possible.

A report has been received on the trial shipment of twenty tons of smoked sheet packed in 75-lb. brick-shaped bales. The manufacturer's comment was generally favourable, particularly with regard to easier handling and storage. Other considerations, however, concerned with shipping and increased cost of packing may prevent any appreciable use of this shape and size of bale.

It has generally been assumed that aluminium vessels are unsuitable for handling latex preserved with ammonia. Some preliminary experiments on the corrosion effects of ammoniated latex on aluminium indicate that this may not be as severe as was thought. Once the initial small reaction has taken place a protective film is formed and no further action is evident. Investigations are in hand on the effect on the latex of storage in contact with aluminium on which such a film has previously been formed.

The heavy demand and high price for sole crepe has attracted the attention of producers to this form of manufacture and many enquiries have been received. To remedy the severe shortage of sodium bisulphite, experiments were carried out to prepare a bisulphite solution by acid interaction with sodium sulphite of which ample supplies were available. Almost theoretical conversion was obtained with sulphuric acid, and a suitable formula for estate use was recommended. The few reports received from users indicated that the method was satisfactory.

The consumer's demand is for a sole crepe of almost water-white colour. This is usually impossible to obtain unless fractional coagulation is adopted, and some producers have trouble in reaching the required standards even after removing a large first fraction. Quite large amounts of clonal latex are now being harvested, some of which produce crepes of objectionable colour. Experiments have been undertaken in co-operation with an estate producing a very fine quality crepe to obtain information on the quality of sole crepes produced from clonal latices. The coagulum from the selected clones was prepared on the Experiment Station under standard conditions without the addition of sodium bisulphite, or the use of fractional coagulation. It was machined to fine crepe, dried

and laminated up to sole crepe on the estate. A wide range of colour was obtained between the sole crepes, varying from a mustard yellow to a dark grey black. Work is in hand to see what improvement can be effected by various treatments on the latex of some of the clones which give very bad coloured sole crepe.

Complaints of softness in sole crepe are beginning to come forward. Preliminary tests to determine the range of hardness which may exist have not so far been very satisfactory. A method of testing the hardness of sole crepe is badly needed and attention is being given to this matter. It is considered that methods of overcoming such defects in the latex can be found and high-yielding material should not be condemned because it may possess an undesirable colour or degree of hardness. Nonetheless, the information may be of value in deciding the siting of monoclonal plots used for replanting, particularly on estates normally producing sole crepe. It would be undesirable, for example, to plant a clone of which the latex might need special treatment next to one of normal character on estates where the latex is collected in bulk by lorry.

Our assistance has been sought on the design of heated drying sheds for the rapid drying of fine pale crepe. A hot-water circulatory system is generally used, and reports indicate that satisfactory drying is achieved in four to five days at a temperature of 90° to 100°F.

The Institute again exhibited at the annual Malayan Agri-Horticultural Association's Exhibition in August. Some time was occupied in preparing the Divisional exhibit, which mainly centred on a scale model of a latex creaming plant with a daily capacity of 2,000 gallons of latex. The model attracted much interest and has since been found very useful in advisory discussions with visitors to the Institute. The all-Malayan Smallholders' Rubber Competition for smoked sheet was held at this show, and the writer together with the Smallholders Advisory Officer acted as judges. The standard of exhibit was good and prizes were awarded for rubber of a super-grade class. It is today impossible to award first, second or third prizes for smoked sheet which do not make invidious distinctions. A number of entries were somewhat sticky and suggestive of coagulation with sulphuric acid. Subsequent laboratory examination of the sheets confirm that over 50 per cent gave reactions which indicated that they were so coagulated.

The supply of acetic and formic acids available during the year has been insufficient to coagulate the tonnage of rubber produced, and large importations of sulphuric acid have been made. Distribution of the approved coagulating acids between the smaller producer and estates has been made as fairly as possible. A system of distribution operated by the Agricultural Department and the Smallholders Advisory Service of the Institute, has endeavoured to ensure that the smallholder receives his acid at the controlled price. The shortage has, however, resulted in the appearance of a large number of different brands of locally made coagulants which are sold to the smallholder by dealers, usually at prices lower than those charged for acetic or formic acids. These acids are usually sulphuric acid of various strengths, and differ widely in their coagulating value. Towards the end of the year a survey of all acids sold throughout the country was undertaken in order that the Rubber Instructors should be able to advise the smallholder on the respective merits of the many brands offered by the dealers. A total of 206 samples representing all brands on sale in the different states and districts throughout Malaya was purchased by the Rubber Instructors and sent to the laboratory for analysis. Of these 88 per cent. were found to be either commercial sulphuric acid alone or mainly sulphuric acid with the addition of small amounts of a mineral acid, usually hydrochloric, which was probably added to give a smell. The normal method of sale is in beer bottles, either large or small, and the amount of acid in the bottles was found to vary very considerably. From a measure of the contents, the analysis of the acid and its sale price the cost of coagulating 100-lb. of rubber was calculated. It is evident that some of these acids are being sold at very inflated prices and the information which is being passed on to each Rubber Instructor concerning the acids sold in his district should be of assistance to him in his advisory work. It is, unfortunately, certain that a good deal of smallholders' rubber is being coagulated with sulphuric acid. This situation must continue until adequate imports and stocks of acetic and formic acids are available.

An analysis of the correspondence of the Division shows that 1,484 letters were received and 1,726 were despatched, whilst 363 visitors were interviewed. These figures indicate the heavy nature of the advisory work. A total of nearly 1,245 samples and specimens were received for examination in the laboratory. These consisted largely of numerous samples of latex sent for examination.

J. D. HASTINGS,
Head of Chemical Division

III. REPORT FOR THE YEAR 1948

The resignation of Mr. J. D. Hastings, Head of the Chemical Division, following shortly on that of Mr. J. H. Pidford, Chemical Engineer, left the Division without the services of any senior research or advisory officer with Malayan experience. Mr. M. W. Philpott joined the Institute on 16th January 1948 and took over as Head of the Division on 1st March when Mr. Hastings retired.

Mr. A. Walker, Chemical Engineer, arrived on 6th March and Mr. G. W. Drake, Physical Chemist, on 8th March. Mr. K. C. Sekar, Assistant Chemist, was on duty throughout the year and Mr. Cheah Sein Liat, Assistant Chemist, was appointed in August.

The staff was further strengthened by the secondment of two experienced officers from London. Mr. H. C. Baker of the staff of the London Advisory Committee for Rubber Research arrived in May, and Dr. G. F. Bloomfield of the British Rubber Producers' Research Association in September.

For most of the Chemical Division staff, particularly for those officers without previous experience of rubber, the year 1948 was a year in which to form an appreciation of the technical problems facing the rubber-growing industry and to prepare a plan of research for execution in the future. As far as possible the demands made upon the Division for immediate information were met and the advisory services were maintained without interruption.

The report that follows is a brief record of progress achieved during the year.

Section I. Chemical and Physical Properties of Latex and Rubber

Because of its complexity the non-rubber constitution of latex, on which the colloidal properties of latex and the vulcanising and ageing properties of commercial rubber so largely depend, is extremely difficult to elucidate by classical analytical methods. Consideration was therefore given to the application of some of the newer techniques that are available for isolating and identifying the constituents of biological systems. Using the method of paper chromatography Mr. Drake separated thirteen constituents of latex protein hydrolysate and identified the following ten: alanine, aspartic acid, glutamic acid, serine, glycine, valine, leucine (and/or

isoleucine and phenylalanine), ornithine, arginine and threonine. The first five were found in considerably larger amounts than the last three. The following aminoacids were not detected in the preliminary trials: histidine, tryptophane, tyrosine, aminobutyric acid, methionine, proline, hydroxyproline and lysine.

Very little is known about the transformations of the phosphorylated constituents of latex, though isolated observations have indicated that breakdown proceeds rapidly in freshly harvested latex. As a preliminary to the study of the degradation and distribution of such constituents a critical examination was made of methods of determining phosphorus in latex fractions. The routine procedure finally adopted was fundamentally that of Barnes *et al.* (*J.I.E.C. Anal.* 1944, 1, 9) coupled with the ashing technique recommended by Van der Bie (*I.R.J.* 113, 499).

Of the 0.1 to 0.2 per cent. P normally found in freshly harvested and dried latex less than 5 per cent. is extractable with ether or acetone. When a sample of serum from frozen latex was dialysed only 6 per cent. of the serum P remained with the undialysable portion. These observations were taken to mean that the organically combined phosphorus is either a small fraction of the total phosphorus or the phosphorylated material undergoes rapid hydrolysis immediately after the latex is withdrawn from the tree.

Fresh latex was therefore tested for the presence of a factor which promotes the breakdown of substances in which phosphorus is organically combined. It was immediately found that fresh latex, or serum, contains a phosphatase which strongly catalyses the hydrolysis of glycerophosphate at pH 5.5 to 6.5: In the initial trials the enzyme activity was measured as follows: citrate buffer, sodium glycerophosphate and fresh latex were mixed so that 100 ml. of the mixture contained 4 ml. of latex and 0.5 gm. glycerophosphate. After incubation at 37°C. the reaction was stopped and the rubber coagulated by acidification, the mixture was filtered and inorganic phosphate was determined in an aliquot of the filtrate. A blank determination was run with latex inactivated by heat. The experiments indicated that:

- (i) The acid serum obtained by coagulating fresh latex with dilute acetic acid retains all the phosphatase activity of the original latex.

- (ii) The amount of glycerophosphate hydrolysed in a given time is approximately proportional to the enzyme concentration but not to the substrate concentration.
- (iii) Maximum activity occurs between pH 5 and 7; within the range pH 5.5 to 6.5 activity is substantially constant. Under strongly acid conditions and above pH 10, the activity is totally suppressed.
- (iv) The activity of the enzyme is reduced or inhibited by zinc, fluoride and cyanide ions.
- (v) Ammonia-preserved latex and serum from two-weeks-old frozen latex show no phosphatase activity.

In view of the possibility that the changes occurring in fresh latex are enzymatically controlled it was decided that Mr. Cheah Sein Liat should undertake an investigation of the latex phosphatase in 1949.

Analyses were made of the various fractions obtained by centrifuging fresh latex after the manner of Homans and Van Gils and it was shown that the heaviest layers after centrifuging (i.e. the lutoid-rich fractions) showed the highest concentrations of N, P, acetone extract, acids and colouring matter. It was thought that if the physical separation of these non-rubber constituents could be made more complete a practical method might be developed of preparing a purer and possibly better grade of rubber. This problem was kept well in mind during the year but none of the methods examined showed promise of being applicable on a commercial scale, chiefly because the lutoid fraction is physically distinguishable only in very fresh latex and becomes inseparable a few hours after collection.

The suggestions is sometimes made that the course of natural rubber synthesis could be directed, perhaps advantageously, if polymerisation-catalysts or enzyme-controlling agents were introduced into the latex system. This possibility is not generally admitted by plant physiologists who believe that interference with the life processes is inherently improbable and, if achieved, is likely to involve the death of the plant. In the case of *Hevea* however nothing is known about the mechanism of latex formation, nor is it clear that the plant is dependent for its growth and health on the normal functioning of its latex system; so that it would be unwise to exclude entirely the possibility of inducing changes in the latex by artificial means.

Arrangements were made to inject a number of 18-years old buddings of B.D.5 selected at random from Field 19 of the Experiment Station. Early in May, during re-foliation, each tree was injected at a height of 5 ft. with 4 litres of reagent solution (concentration 2 or 4 millimols per litre) and was sampled on three successive tapping rounds before and three after injection. Further samples were taken about one month after injection. Observations were made on the yield and d.r.c. of the latex obtained before and after injection, and also on the hardness (D_{10}) of the rubber, since it was believed that differences in rheological behaviour would be evidence of differences in the state of polymerisation of the caoutchouc.

The injected reagents included substances which might be expected (a) to change the oxidation-reduction balance of the tree fluids (ferrous and ferric salts, potassium persulphate, ascorbic acid), or (b) to sequester heavy metal ions (sodium sulphide, sodium diethyldithiocarbamate, thiourea, 8-hydroxyquinoline, 2:3 dimercaptopropanol).

None of the observed differences in latex d.r.c. or rubber hardness before and after treatment could be confidently attributed to the injected substances, nor did chemical analysis of the latex from iron-injected trees give clear evidence of penetration by the injected substances to the latex system. In view of this negative result, which was not unexpected, it was decided to discontinue the investigation.

It is a matter of common observation that the fluidity of latex on the tapping cut varies from tree to tree in a mixed stand. Some trees consistently yield free-flowing latex and some yield latex which is extremely viscous. The condition appears to be a characteristic of the tree (or clone) and extreme conditions are found among both high- and low-yielding trees.

As the factors which regulate the fluidity of fresh latex are not known ten trees yielding thick latex and ten yielding free-flowing latex were ammoniated in the field and brought to the laboratory for examination. No single factor was found to correlate with thick latex on the tapping cut, and when the viscosities of *ammoniated* latices were plotted against total solids content all the points except one were scattered about a single curve. There was indication that the pH of latex on the cut tended to be lower for thick than for thin latices but the observed differences were not statistically significant.

Because of its bearing on the out-turn of lower grades on estates, and hence on the economics of production, the elucidation of the causes of high viscosity in field latex is considered to justify further investigation.

Section II. Chemistry and Technology of Latex

LATEX PRESERVATION

Mr. K. C. Sekar reviewed the search, conducted over many years, for chemical agents capable of preserving latex either alone or in the presence of small concentrations of ammonia. Many trials were repeated in order to test earlier observations and the data were tabulated and classified in the hope that it would be found possible to make useful generalisations. As an example of the possible value of this empirical approach it may be noted that the only cations which have so far shown evidence of preservative action are metals which form insoluble sulphides at the pH of lightly ammoniated latex.

Modern theories of germicidal action may suggest new lines of attack on the problem of latex preservation. The steric resemblance of pentachlorophenol to inositol, for example, suggests that this active preservative may function as an antagonist in the metabolism of the micro-organisms responsible for latex putrefaction and coagulation. Nothing is known about the metabolic requirements of latex organisms but it is a reasonable guess that quebrachitol, the main carbohydrate constituent of latex, is utilised even if it is not an essential metabolite. On this assumption the methyl ether of pentachlorophenol (pentachloranisole) might be expected to be a better preservative than pentachlorophenol itself. Experiment showed however that neither pentachloranisole nor hexachlorbenzene (which also has a structure related to that of pentachlorophenol) possesses preservative properties.

A preservative of some theoretical interest is 8-hydroxy-quinoline 0.1 per cent. of which, in conjunction with 0.1-0.2 per cent. of ammonia, preserves latex for long periods. The activity of this substance might be explained on the assumption that it combines with trace metals which are necessary for the activation of enzymes present in the latex or in the associated micro-organisms.

In the report for 1947 it was noted that zinc dimethyldithiocarbamate in concentrations as low as 0.1 per cent. is capable of preserving latex containing 0.1 per cent. ammonia. It is now known that the corresponding soluble

sodium salt is appreciably less active, and that among zinc dialkyldithiocarbamates the dimethyldithiocarbamate is more active than the diethyl-, dibutyl- and dipentamethylene-compounds. From a large number of tests with related substances it was concluded that in zinc dimethyldithiocarbamate both the anion and the cation exercise a preservative effect on latex.

The well-known capacity of ammoniated latex for being destabilised by zinc oxide has probably diverted attention from the idea of using zinc compounds as preservatives. There is evidence however that if zinc oxide is added to latex soon after collection it retards the hydrolytic breakdown of the stabilising system and the latex maintains, for a few weeks at least, a stability which is relatively little affected by subsequent compounding additions of zinc oxide. Unfortunately trials have shown that latex preserved with a zinc compound (*e.g.* oxide or borate) in conjunction with a low concentration of ammonia becomes progressively unstable on long storage. It seems probable that this will prove to be an insuperable obstacle to the use of such combinations in the preservation of commercial latex, but nevertheless the preservative effect of zinc ions is thought to be of sufficient interest to justify preparing a set of zinc-preserved latices for further observations. Compounds of cadmium and of several other metals (Hg, Cu, As, Ag, Tl, all of which form insoluble sulphides at pH 9-11) have also been found to possess preservative properties.

Although it is generally agreed that early ammoniation is essential for the preparation of stable preserved latex there appear to be no quantitative data to show by how much stability is impaired when the addition of preservative to field latex is unavoidably delayed. An experiment was therefore set up in which latex was ammoniated (0.7 per cent) as soon as possible after collection and compared with the same latex ammoniated one, two and three hours later. Parallel observations were made on the same latex treated immediately with formaldehyde (0.2 per cent.) and subsequently with ammonia after zero, one, two and three hours. Preservation by formaldehyde and ammonia is the subject of B.P. 368, 193 and is the procedure followed by at least one large producer of centrifugal concentrate in Malaya.

Determinations of stability, KOH No., and the free and combined acids of the alcoholic extract were made on the latices after ten days storage. The results, which give an indication of the changes which take place during the short period between collecting and preserving field latex, showed

that in three hours, combined acids of the alcoholic extract are liberated in amount equivalent to about 50 mgm. of KOH per 100 gms. of latex solids; roughly half of these acids being ether-soluble and half water-soluble. The KOH No., which is a measure of the total titrable acid constituents of the latex, increases by about 120 mgm. per 100 gms. latex solids, the balance 70 mgm. of the KOH No. being accounted for by the decomposition of sugars etc., the degradation of protein and consequent liberation of amino-acids. The concomitant change in stability is represented by a drop in L.A.C. (zinc oxide) stability to little more than half that of the promptly-preserved latex. It is interesting to note that all these changes appear to be prevented by the early addition of formaldehyde and that latices thus preserved tend to be more stable than the controls. Typical results are tabulated below.

TABLE I

Delayed Ammoniation—Effect of Formaldehyde on Zinc Oxide Stability (thousand revs.)				
0.7% NH ₃ added after hours	Ulu Klang Latex		R.R.I.E.S. Latex	
	Without HCHO	0.2% HCHO added at zero hours	Without HCHO	0.05% HCHO added at zero hours
0	56.3	74.0	66.7	78.0
1	46.7	65.6	54.4	75.8
2	33.1	74.2	36.7	77.9
3	34.4	71.7	38.3	71.2

LATEX TESTING METHODS

An appraisal was made of the methods put forward by a committee of the British Standards Institution for sampling latex and determining d.r.c. and total solids content.

The d.r.c. of formaldehyde-preserved latex cannot be successfully determined by the B.S.I. method. Neither acetic nor sulphuric acid gives a clear serum or a coherent coagulum. Alcohol can be used for coagulation but the results are 0.5 to 1 per cent. low. It was found that the B.S.I. procedure could be followed with satisfactory results if 0.5 to 1 gm. of ammonium acetate or sulphate was first added to the 25 gms. of latex taken for the test.

Attention was given to the latex straining test of Brass and Slovin (*Anal. Chem.* 1948, 20, 172) which is considered by one large latex user to be a reliable index of processing quality. The test consists in measuring the volume of preserved latex that can be passed through unit area of a standard felt before the felt chokes. The test was studied chiefly in relation to the statement of a Malayan producer that smallholders' latex is unsuitable for preparation as preserved latex because it has poor straining properties. Latices from many sources were tested: from estates and smallholdings; from dirty (*i.e.* typical) smallholdings and clean (*i.e.* exceptional) smallholdings; from old and young trees; from buddings and seedlings. All sources included both good and bad straining samples; large differences in straining capacity were found between individual trees and also between tappings of the same tree. No general improvement was obtained by substituting clean tapping cups for dirty ones nor by adding formalin to the cups. The effect of inducing slight putrefaction by delaying the addition of preservative was, if anything, to improve the straining properties. The significance of the test remained obscure and plans were made for further investigation.

One obstacle to the use of sodium pentachlorophenate as a preservative is the lack of a satisfactory routine method of determining its concentration in latex. Mr. Drake made a short investigation of a method which involves acidifying the latex with sulphuric acid, steam distilling and determining pentachlorophenol in the distillate as the silver compound. Coagulation of the latex by sulphuric acid was satisfactorily prevented by the addition of 2 per cent. Santomerse D but it was found that the rate of distillation of the phenol was inconveniently low. Co-distillation with higher boiling-point substances was tried without success.

LATEX CONCENTRATION

Ammonium alginate continues to be the most generally favoured creaming agent and most of the large producers of creamed latex import an American grade which contains about 10-12 per cent. of moisture. An alternative material from a sterling source is an inferior creaming agent, contains 40-60 per cent. of moisture (depending on the prevailing humidity conditions) and is very variable. A new British product, nominally of 80 per cent. solids content (not available commercially) was found to approach the American product in creaming efficiency.

A new synthetic creaming agent described as a 15 per cent. aqueous solution of "the ammonium salt of a synthetic polymer" was compared with ammonium alginate, and found to be a satisfactory creaming agent possessing no obvious advantages over ammonium alginate.

A commercial cellulose ether proved to be unsuitable as a creaming agent because it left too high a concentration of solids in the underlayer (18-20 per cent.). A "sodium salt of a cellulosic acid" on the other hand was found to possess creaming properties of the same order as ammonium alginate.

The improved creaming capacity which latex acquires on storage in the presence of ammonia has generally been ascribed to the formation of ammonium soaps. Evidence was obtained however that the improvement is connected with the elimination of sludge from the latex. Centrifugal clarification of freshly-ammoniated latex was found to assist creaming as effectively as undisturbed storage, suggesting that any treatment of freshly-ammoniated latex which accelerates or promotes the separation of sludge will also improve creaming properties.

The claim (B.P. 599,006) that sodium pentachlorophenate assists the creaming of ammonia-preserved latex was examined and it was concluded that the claim is justified when the creaming agent is a vegetable gum (*e.g.* tragon seed gum) but not when alginates are used.

INSTABILITY OF GLENSHIEL 1 LATEX

It has been reported elsewhere that clone Glenshiel 1, despite its excellent yield record in Malaya, has fallen into disrepute because of the characteristic instability of its latex. For the production of concentrate G.1 latex is generally either rejected or is mixed in small proportions (not exceeding 10 per cent.) with latex from other sources. The discovery of a remedy for the defective quality of G.1 latex would be of considerable benefit to the industry.

In a preliminary study of the effect of adding artificial stabilisers to ammoniated G.1 latex it was found that lecithin, casein and many synthetic surface-active agents were almost ineffective but that a marked improvement in stability was obtained with soaps and with sodium taurocholate. It was noted particularly that ammonium or triethanolamine soaps of the C_{10} (capric) and C_{12} (lauric) normal fatty acids were more effective stabilisers than soaps of shorter or longer chain length. An abstract of the results is given in Table II.

TABLE II

Effect on Stability of Ammonium and Triethanolamine (TEA) Soaps						
Acid	Concentration gms. soap per 100 ml. latex		Stability			
			ZnO (L.A.C.) (thous. revs.)		Mechanical, mins.	
	Ammonium Soaps	TEA Soaps	Ammonium Soaps	TEA Soaps	Ammonium Soaps	TEA Soaps
None ..	—	—	4.0	4.0	3.5	3.5
Myristic ..	0.081	0.125	5.6	4.7	5.5	5.9
Lauric ..	0.072	0.115	9.0	8.1	21.8	17.1
Capric ..	0.062	0.106	5.8	5.8	21.7	27.0
Caprylic ..	0.053	0.097	4.5	4.4	6.8	8.0

Centrifuge trials were carried out with G.1 latex and with B.D.5 latex for comparison. Mixed coconut oil fatty acids, (mainly lauric and myristic, saponification equivalent 206) were added to the input latex as ammonium soap in the proportion of 0.1 per cent. acids on the latex. The properties of the concentrates are shown in Table III.

TABLE III

Centrifuge Concentrate from G.1 and BD 5 Latex, with and without Soap				
Latex	Properties of Concentrate			
	T.S. %	Surf. Tension at 40% T.S. dynes/cm.	Stability	
			Zinc Oxide (LAC) thous. revs.	Mechanical mins.
BD 5; without soap	60.75	38.9	10.6	4.0
BD 5; with soap ..	61.38	37.8	17.6	27.0
G.1; without soap ..	59.03	39.3	3.6	2.1
G.1; with soap ..	60.81	37.0	4.8	12.4

It is evident that the *mechanical* instability of G.1 latex can be corrected by the addition of an appropriate stabiliser in very small amount but that other remedies may have to be found for improving the chemical (zinc oxide) stability.

Section III. Chemistry and Technology of Dry Rubber

Although estates are normally advised to ensure the production of clean, uniform rubber by bulking and settling their latex before coagulation it must be admitted that the procedure is often impracticable because it delays the completion of factory operations. This objection is valid however only so long as we insist that field latex should be coagulated on the day of collection; if we discard this principle and resort to the use of temporary preservatives to keep latex in fresh liquid condition for 24 hours or more it becomes feasible to assemble one day's crop in a single bulk, clean it by settling or clarifying, and coagulate it at leisure on the following day. Such a change in preparational procedure would however prompt the question whether the preservative and clarification treatments might not affect the quality of the product. A 5 x 3 x 2 factorial experiment was therefore set up to test the effects of the following treatments:

- | | |
|------------------------|---------------------------------|
| (i) No preservative | (a) No clarification |
| (ii) Formaldehyde 0.2% | (b) Clarification by centrifug- |
| (iii) Ammonia 0.1% | ing at 6,000 r.p.m. |

The experiment was carried out with latex from five sources (mixed seedling, Tj.1, P.B.86, P.B.186, G.1) and the latices were coagulated, machined and smoke-dried under standard conditions.

From a comprehensive examination of the smoked sheets produced it was concluded that none of the treatments—preservative or clarification—improved or impaired the technological properties of the rubber. Differences between the five sources of latex were greatest for the flow properties of the raw rubbers, less for the mechanical properties of the pure gum vulcanisates and least for those of the carbon black—reinforced vulcanisates.

Three "soft rubber" clones planted in Field 35 (budded 1939) were brought into tapping during the year. Although the mother-trees from which these clones were derived all yielded very soft rubbers none of the clonal rubbers was exceptionally soft.

Rubbers prepared from a number of high-yielding individual trees were compared technologically. They covered a wide range of plasticity and exhibited important differences in vulcanising properties. Mooney viscosity, hardness (D_{10}) and gel content were found to be closely correlated but the

results did not bear out the expectation that resilience (after vulcanisation) is positively correlated with raw rubber hardness or with gel content. Removal of 10 per cent. low molecular weight material from raw rubber by extraction with benzene/methanol did not appreciably affect the physical properties of the vulcanisates obtained.

Evidence was obtained that sheet rubber prepared from latex containing a hardening agent (benzidine) gives carbon black-reinforced vulcanisates of abnormally high resilience. The effect, if real, is small and may prove to be technologically unimportant, but it is interesting to note that Parkinson and Blanchard (*Trans. I.R.I.* 1948, 23, 259) have made similar observations with benzidine-treated rubber which they ascribe to an increased breakdown of carbon structure during mixing (decatenation) and the formation of more carbon-rubber attachments at the expense of carbon-carbon attachments.

Section IV. Preparation Practices

PALE CREPE

Enquiries are frequently received about the prevention of enzymatic discolouration and the removal of yellow colour from latex in the preparation of pale crepe. The purple-grey discolouration which occurs in latex on exposure to air has been ascribed to oxidases acting on phenolic or other substrates in the latex. Latices from different trees (and clones) vary widely in their discolouring propensities and in their capacity for producing pale crepe without special treatment. The tendency to discolour is most marked at pH 3 to 4 and is usually adequately suppressed by addition of sodium bisulphite in concentrations of the order of 1 part per 1,000 parts of latex. It has now been found that discolouration is also prevented by certain sulphur compounds, particularly compounds containing an—SH group, in concentrations as low as 1 part in 50,000. Examples of such compounds are thiourea, thioglycollic acid, thiomalic acid. Effective in higher concentration (1 in 5,000) are alkali sulphides, mercaptobenzthiazole, glutathione, sodium diethyldithiocarbamate, 2:3 dimercapto-propanol. It does not appear that these inhibiting agents possess any practical advantage over sodium bisulphite but from their nature it may be possible to learn something about the enzyme system responsible for latex discolouration. Thus thiourea is known to inhibit systems which are activated by copper.

As far as we know, the natural yellow pigment of latex cannot be destroyed by any chemical reagent which leaves the rubber intact, and it is therefore customary in the preparation of white crepe, to eliminate it partially by the method of fractional coagulation. The intensity of the yellow colour is a clonal characteristic and with some clonal latices it is difficult to obtain a satisfactorily pale colour by this method. A set of crepe samples was therefore prepared from latices of the more widely planted clones and was used as a basis for advising enquirers about the suitability of particular clones for the preparation of pale crepe.

COAGULANTS

Several importers have submitted samples of acetic acid in aluminium drums for testing. It is understood that drums are a cheaper form of packing than glass carboys. The acid is satisfactory for rubber coagulation.

Glycollic acid was proposed several years ago as a latex coagulant (B.P. 552,023) and is now available in commercial quantities. A sample was examined and found to be 15-20 per cent. more efficient as a coagulant, weight for weight, than commercial formic acid (90 per cent.), but unless used in excess it tended to produce bubbly sheet. The technological properties of glycollic acid-coagulated sheet were normal.

DRY SHEET RUBBER

Progress in the practice of drying rubber is held up by the lack of fundamental knowledge on the physical processes involved. Until this information becomes available it is necessary to consider whether any advance can be made empirically.

It has been noticed that machined coagulum prepared from latex to which a heavy metal salt has been added dries abnormally quickly. The usual result of adding salts is to retard the drying of coagulum and it seems possible that in the exceptional instances where drying is accelerated some modification of the protein network occurs which facilitates the diffusion of water. In a series of trials with protein precipitants and tanning agents quick drying was obtained with formalin and urea, but not with phosphotungstic, sulphosalicylic, tannic and picric acids. The addition of 0.25 per cent. (on the rubber) of zinc sulphate or lead acetate to sheet reduced the time of air drying at 50°C. from eight to five days. In another trial the combined use of formalin

and zinc salt reduced the drying time from ten to four days. Normal estate sheet made from latex containing 0.2 per cent. on the diluted latex of formaldehyde dried in three days in the Experiment Station smoke-house instead of four days for normal sheet.

RUBBER PACKING

An enquiry was made into the origin of recent complaints of bad packing, and contemporary practices were studied in Singapore. The results of this enquiry were summarised in a separate memorandum (C/M 17(48)).

For safe stacking without distortion a bare-back bale should be hard-pressed and flat-sided. Many bales, particularly godown-packed bales which are not usually kept under pressure long enough to give them a good shape, emerge from the packing shed with bulging sides. In an attempt to improve the shape of quick-pressed bales the flat top and bottom boards of one of the baling boxes at the Experiment Station were replaced by convexly dished boards. The Manager, R.R.I. Experiment Station, has recorded that he considers the regularity and rectangular shape of the bales to have improved since the special boards were introduced.

ACCELERATED COAGULATION

Elsewhere in this report it has been suggested that the preparation of clean, uniform rubber in large central factories may entail abandoning the principle of coagulating latex on the day of collection. The day's crop, it is assumed, would be kept overnight in liquid form, coagulated early on the following morning and machined immediately. Since to work to such a schedule would necessitate cutting down the period between coagulating and machining, it becomes a matter of interest to know what means are available for speeding up the rate at which coagulum forms. The question is also important in relation to the adaptation of the L.A.C. continuous coagulation process to fresh latex.

Use was first made of the known capacity of soaps to accelerate coagulation (B.P. 537,645). Contrary to statements in the literature (*J.I.E.C.* 1947, 39, 978) ricinoleic acid soaps were found to be not exceptionally active and attention was therefore confined to soaps of common occurrence such as ammonium oleate and laurate. Accelerated coagulation was observed with several synthetic detergents (Na lauryl sulphate, Santomerse B, Teepol) but generally the effect of these

materials was less marked than that of soap. It was concluded that 2-minutes coagulation could be obtained in factory practice by using any of the following combinations of soap and coagulant per 1,000 parts dry rubber:

TABLE IV

Soap	Acid			CaCl ₂
	Acetic	Formic	Sulphuric	
10	10	—	—	—
8.4	—	5	—	—
6.7	—	—	5	—
6.7	—	—	—	20
6.7	3.3	—	—	3.3
6.7	—	2.7	—	3.3
6.7	—	—	2.4	3.8

Section V. Miscellaneous

The Division assisted the Pathological Division to determine the concentration of copper on leaves sprayed with different copper sprays. There was also close co-operation with the Smallholders' Advisory Service over matters concerning the quality of smallholders' latex and the establishment of a smallholders' group factory.

ADVISORY WORK

Interviews at the Institute	..	270
Visits to Estates etc.	..	86
Letters and Reports	..	2,150
Samples examined	..	1,360

During the latter part of the year there was a decrease in the amount of advisory correspondence. This is attributed partly to unsettled conditions on estates and partly to a flagging interest in latex production. A large proportion of the enquiries related to drying problems. Advisory and "paper" work detract considerably from the usefulness of the Division as a research unit but the remedy is hard to find. As far as possible all non-research duties are performed by

the Head of Division and Chemical Engineer so that other research officers can carry out their programmes without distraction.

PUBLICATIONS

Chemical Division Information Cards (Revised 1948)

C/AL 11(48) Notes on the Preparation of Sole Crepe.

C/AL 1(48) R.R.I. Tunnel Smoke-House.

C/M 17(48) Packing Raw Rubber.

M. W. PHILPOTT,

Head of Chemical Division

KUALA LUMPUR

20th April, 1949

REPORT FOR THE PERIOD SEPTEMBER 1945 TO DECEMBER 1948

EXPERIMENT STATION

I. SEPTEMBER-DECEMBER 1945

The first visit to the Experiment Station after the Japanese capitulation was made on the 1st October, 1945, by the Director, Mr. H. J. Page, Mr. H. F. Smith and Mr. G. Owen. The following is an extract from the Director's report at that time:—

“ At the Institute's Experiment Station at Sungei Buloh practically all the Asiatic staff and most of the labour force are still there. Although the bulk of the labour force of adjoining commercial estates was sent to Siam by the Japanese, the special status of the Experiment Station was recognised by them, and the labourers were left unmolested. Similarly the plant and machinery there, even the aluminium tanks and sheeting, were not taken away. Although the greater part of the planted area was not upkept, the rubber trees were not interfered with or damaged; certain areas, notably the large-scale trial plots of the new R.R.I. 500-series clones, were upkept. On the more recently planted area the rubber trees are of subnormal girth and rather drawn up, but they have held their own, and will undoubtedly show very rapid increases in girth as soon as they are cleaned up. The older trees cannot but have benefited greatly by their three to four years' rest, so far as potential yield is concerned.”

More detailed information on the condition of the Experiment Station is contained elsewhere in this report. It was apparent that much work would be necessary before the Station was again in good running order.

PROGRESS OF THE WORK

Early in September the work of the Station was resumed, and although progress was slow, owing to the poor health and living conditions of the labourers, a considerable amount was done. A start was made with weeding, slashing of natural covers, eradication of lalang and clearing paths for tappers.

The hill road was repaired where slips had occurred. In Field 38 (budded 1941) a start was made on thinning-out doubles.

MULTIPLICATION NURSERIES

Most of the budwood nurseries were intact, but much overgrown and in need of cutting back. Some cutting back was done to allow a fresh crop of budwood to grow.

PESTS AND DISEASES

Root disease. Inspection and treatment were re-started; 131 trees were treated and 112 trees were removed.

Inspection and treatment of Termites and Pink disease were also carried out. Tin mine arsenic was available for treatment of Termites.

TAPPING

As from the 18th September areas were gradually brought into tapping, and at the end of the year 469 acres were being tapped. No records were kept, but preparations were made to start recording in 1946.

Crop harvested

		R.S.S. lb.	Lower grades lb.
September	..	2,840	160
October	..	13,900	1,094
November	..	18,471	1,542
December	..	29,090	2,363
		64,301	5,159

MEASUREMENTS

Recording of girth measurements commenced in October in the Botanical and Soils Divisions areas.

CURING

Coagulating tanks complete with aluminium partitions were available to take all the crop produced.

The five horse-power Lister engine was used to run the sheeting battery, and worked satisfactorily. The crepeing battery required repairing and could not be used for lower grades.

Smoke-house accommodation was sufficient for immediate needs.

Fermented toddy was used for coagulation.

No baling was done, and sheet was sold loose.

LOSS OF RUBBER

In November 7,600 lb. of sheet rubber were stolen from the packing shed by gang robbers.

WATER SUPPLY

All water was pumped from the stream in Field 22. Two engines were used, one on loan from Hawthornden Estate.

LABOUR

The position in December was:—

	Workers	Dependants
Men ..	143	2
Women ..	106	6
Children ..	36	129
	285	137

Medical supplies were very scarce, and many labourers were suffering from malaria, anaemia and malnutrition.

STAFF

After the Director's visit in October, Mr. B. T. Hassan, Chief Clerk, and Mr. M. K. Nambiar, Senior Field Assistant of the Botanical Division, were appointed joint administrators of the Experiment Station. Mr. H. F. Smith, and later Mr. C. C. T. Sharp, as Acting Director, paid periodical visits to the Station.

The following were on duty, or reported for duty during this period:—

Experiment Station Staff

- 1 Chief Clerk
- 1 Assistant Clerk
- 1 Typist
- 1 Tapping Field Assistant
- 1 Junior Field Assistant
- 1 General Field Assistant
- 1 Factory Assistant
- 1 Dresser

R.R.I. Divisional Staff

- 7 Botanical Division Field Assistants
- 1 Soils Division Field Assistant
- 2 Pathology Division Field Assistants

II. REPORT FOR THE YEAR 1946

Acreage

Planted 1928-1941	..	..	1,221.00	acres.
Previously planted, now under food crops			10.25	„
Building site and roads	..	..	66.18	„
Reserve land	..	..	54.07	„
			1,351.50	„

Planted Area

Mature rubber	..	..	910.00	acres.
Immature rubber and nurseries		..	311.00	„
Under food crops	..	..	10.25	„
			1,231.25	„

Not included in the above statement are the following areas:—

Two isolated seed gardens in the Forest Reserve	..	..	10	acres.
Planted during Japanese occupation in Government Nursery area		..	10	„

Distribution of land

Botanical Division	..	..	912.50	acres.
Soils Division	..	..	258.50	„
Pathological Division	..	..	16.00	„
Chemical Division	..	..	34.00	„
			1,221.00	„

Field Work

LALANG. Lalang was eradicated in all but a few areas, and the fields are now under periodical patrol.

SLASHING COVERS. Natural covers were slashed to three or four feet and are now under control in all fields.

WEEDING. By the end of the year all fields were included in normal weeding rounds.

DRAINS. All drains on the Station received attention during the year. A large amount of work is still necessary to prevent further erosion.

ROADS AND BRIDGES. Some repairs to roads and bridges were effected, but much still remains to be done on the hill road.

UPKEEP OF BUNDS AND TERRACES. Repairs were started to the terraces after the eradication of lalang but were still uncompleted at the end of the year.

AREAS FELLED. In Field 18C nearly all the remaining trees were cut out and used for firewood.

Pests and Diseases

ROOT DISEASE. Inspection and treatment of root disease were carried out. Root disease was found to be worst in the younger plantings, but even there the incidence of the disease was not serious. Field 38 (59 acres, budded in 1941) is typical of the immature areas under natural covers and may be cited as an example.

Field 38—incidence of disease

		Cases per acre		
		Total	Treated	Removed
Fomes lignosus	..	1.76	1.28	0.48
Fomes noxius	..	1.43	0.96	0.47
Ganoderma pseudoferreum		0.79	0.27	0.52
Ustulina zonata	..	0.50	0.37	0.13
		<u>4.48</u>	<u>2.88</u>	<u>1.60</u>

In no field did the total number of cases exceed five per acre; losses did not exceed two per acre.

Total for all fields

		Treated	Removed
Fomes lignosus	..	393	167
Fomes noxius	..	157	99
Ganoderma pseudoferreum		153	90
Ustulina zonata	..	161	71
		<u>864</u>	<u>427</u>
Stormblown trees	..	—	528
White ants	..	1,971	113

PINK DISEASE. In all the young areas the trees were inspected and treated for pink disease.

Crop

Details of the crop harvested and manufactured during the year are as follows:

R.S.S.	552,139 lb.
Scrap	36,601 lb.
Cup lump	27,644 lb.

The seventeen horse-power Ruston Hornsby engine was used to drive the sheeting battery, since the five horse-power Lister engine was required to drive the water pump.

One coagulating tank which was acquired during the Japanese occupation was returned to the owners. Two new coagulating tanks, complete with aluminium partitions, were purchased from Messrs. Diethelm & Co., Singapore.

Sulphuric acid was used for coagulation for a few months, until supplies of formic acid were again available.

SMOKEHOUSES

Two new temporary smokehouses were constructed early in January to deal with the increased crop. Two old tunnel smokehouses and the converted A.P.C. drying shed were in use throughout the year.

A large new tunnel smokehouse was constructed during November and December. It consists of one large chamber with two sets of rails, each carrying eight trucks. The walls are of timber with asbestos lining, and there are two furnaces, both on one side, with flues leading under each set of rails. Each truck takes 1,000 lb. of rubber, and it is hoped to deal with a crop of 4,000 lb. per day.

TAPPING

The area in tapping was gradually increased from 512 acres in January to 718.5 acres in December. The total tappable acreage was 910 acres. During the last two months of the year tapping was interrupted by labour troubles, as a result of which about 30 per cent. of the area was untapped for one-and-a-half months.

In April, owing to a shortage of Tamil tappers, about 25 Chinese contract tappers were employed to tap the non-experimental areas. They continued to work throughout the year.

The number of normal tapping days was 280; late or interfered tapping was done on 31 days, and there was no tapping on 54 days. The total crop harvested was 616,384 lb.

Experimental

Tapping and recording the yields commenced in the following fields:

Field	Date of Recording	Date of Planting or Budding	Experiment
2	.. January	1928	Illegitimate seedling trial.
3	.. "	1930	Small-scale trial of 500-Series Clones.
5	.. "	1929	Large-scale clone trial.
	.. "	1929	Tapping experiment.
5 A	.. "	1938	Small-scale clone trial.
6	.. May	1928	Manuring experiment.
	.. "	1928	Tapping experiment.
12	.. January	1936	Illegitimate seedling trial.
14 A & B	.. "	1931	Small-scale trial of 500-Series Clones.
14 C & D	.. "	1930	Density-of-Planting Experiment.
15	.. "	1931	Trial of Clones from Estate mother-trees.
15 A	.. May	1936	Clonal seedling trial.
16 F	.. August	1935	Stock experiment.
17 B	.. January	1935	Small-scale clone trial.
20 A	.. June	1933	Illegitimate seedling trial.
23 A	.. May	1936	Illegitimate seedling trial.
25 (6)	.. January	1935	Small-scale clone trial.
26	.. July	1933-34	Illegitimate seedling trial.
30	.. January	1937	Large-scale trial of Clones 500-522.
32	.. July	1939	Small-scale clone trial.
33	.. "	1939	Small-scale clone trial.
33 B	.. April	1939	Legitimate seedling trial.
34 A	.. May	1940	Legitimate seedling trial.

BOTANICAL DIVISION. IMMATURE AREAS

Field 38—59 acres—budded December 1941

A large number of points contained two or more trees and these were thinned out to one per point.

The wire fences marking plot boundaries had all disappeared, but the staff of the Botanical Division were able to re-trace the boundaries.

Fields 41 and 42—budded 1942

All doubles were removed and the tree rows were cleared of belukar.

The condition of the above fields, which were budded late in 1941 or during the Japanese occupation, was very satis-

factory, and credit is due to those who were responsible for the upkeep of these areas at the critical stages.

Later, natural covers were allowed to grow unchecked, but the effect on the growth of the trees has not been unduly severe.

Field 43—13 acres—Stock Experiment 1941

This field was not in such good condition as the others. Large sections were under lalang, and elsewhere the jungle growth was very heavy. Considerable damage had been done by white ants, and there were many vacancies, greatly reducing the value of this experiment. All doubles were thinned out, but they were too large to be transplanted to vacancies.

Field 45—10 acres—planted 1942-43. Hand-pollinated seedlings

This field was under heavy lalang and growth had suffered considerably. The lalang was cleared during the year, and the trees are coming away well. There are not many vacancies, and the field will be of considerable value to the Botanical Division.

Multiplication Nurseries

All nurseries were cleaned up and vacant land was planted with germinated clonal seed. In the budded sections all large plants were cut back to allow a fresh growth of budwood. All beds were checked and labelled.

Large quantities of budwood of the R.R.I. 500-series are available.

Sale of Planting Material

Sixty yards of budwood of R.R.I. clones were supplied to one estate and 120,000 mixed clonal seed were supplied to the Department of Agriculture.

SOILS DIVISION AREAS

Field 31. This field has made excellent growth and is now ready for tapping. Some thinning out was done.

Measurements. Girth measurements were taken in all Soils Division fields.

CHEMICAL DIVISION

Baling

Experiments were carried out with 75 lb. bareback bales. In October a consignment of 20 tons was shipped to London, and a report will be made on this.

General

ANTI-MALARIAL WORK. As a result of past neglect the streams in Fields 18 and 19 were badly silted, causing flooding of the surrounding areas and forming excellent breeding places for anophelene mosquitos. These drains were cleaned out twice during the year and new surface drains dug where necessary. A considerable amount of work was done in the areas just outside the boundaries, where food crops which had been cultivated during the war had been neglected later. Many chains of drains were dug to clear up the swampy places, and regular oiling rounds were initiated.

MEDICAL AND HEALTH. There was a gradual improvement in health as medical supplies became more plentiful. During September to November there was an epidemic of measles among the children. All the cases were sent to hospital. Three hundred and seventy cases were treated for malaria locally, and 591 were treated for various other diseases. There were fourteen births and six deaths.

LABOUR. Labour was very unsettled during the year. Wage rates were increased in June to \$1.10 for men and 95 cents for women per day, but the high cost of living and the scarcity of clothing caused much discontent and agitators found fertile soil to work on. Discipline and the standard of work were poor, but this had to be accepted because of the scarcity of labour. When the question of authority on the Station arose a firm stand had to be taken, and after a strike lasting 28 days during November and December, about 130 Indian labourers were paid off or had left the Station. Such a large number would not have left had not arrangements been made during the strike to employ them on another estate.

The labour position on 31st December was as follows:—

Men	..	..	77
Women	..	..	61
Children	..	..	24

162

In addition, 30 Chinese and 15 Javanese contract tappers were employed.

FOOD CULTIVATION. Ragi, maize, tapioca and sweet potatoes were grown in all suitable areas. Very poor results were obtained on the sandy soils owing to the lack of manures; damage by pigs and loss by theft were also common. There was no great demand among the labourers for these foodstuffs.

BUILDINGS. The old bucket store was fitted up as a temporary office. The Guest House was repaired and occupied temporarily by the Assistant Manager. Other temporary buildings erected during the year were a scrap drying shed, a petrol and oil store, and a muster and tool shed. Minor repairs were carried out to other buildings and a start was made on painting (preservative) and white-washing.

WATER SUPPLY. All water used on the Station was pumped up from the stream in Field 22. Two new concrete bunds were built to control and facilitate cleaning the reservoir. The two engines were overhauled.

LIGHTING. No electricity was available during the year and extensive repairs and renewals are still required.

RAINFALL. No gauge was installed until July. The total rainfall from July to December was 51.11 inches. Rain fell on 87 days.

VISITORS. There were 68 visitors to the Station.

STAFF. Mr. B. T. Hassan and Mr. M. K. Nambiar continued as joint administrators until April, when Mr. Nambiar went on leave to India. Mr. Hassan continued in charge until the end of May. The Manager, Mr. D. S. Thomson, returned on 30th May after six months' leave following three-and-a-half years as a prisoner-of-war. The Assistant Manager, Mr. R. F. Harley, returned on 15th July after two months' leave following four-and-a-half years in the Army. Mr. J. H. Tovey, who was Assistant in 1941, has resigned.

The writer wishes to record with appreciation the valuable assistance given by all members of the staff who have spared no effort to get the Station into good order again.

REPORT FOR THE YEAR 1947

Acreage

Planted 1928-1947	..	..	1,226.25 acres.
Previously planted, now felled	..	..	18.00 "
Building Site and Roads	..	..	64.43 "
Reserve land	..	..	52.82 "
Total	..	..	1,361.50 acres.

Planted Area

Mature Rubber	..	..	..	1,087.00 acres.
Immature Rubber—				
Planted to end of 1941,	93.50	acres.		
,, 1942-1943,	10.00	"		
,, 1947,	1.25	"	104.75	"
Nurseries	..	..	..	34.50 "
Total	..	..	..	1,226.25 acres.

Not included in the above statement are two isolated seed gardens totalling 10 acres in the Forest Reserve. These areas are held under permit and are reserved for work on *Hevea spruceana*.

New Clearings—Field 46. A small area ($1\frac{1}{4}$ acres) of the old garden site north of Field 43 was planted as an experiment on planting land under heavy lalang. Three to four germinated seeds of clone Tj.1 were planted at fifteen feet by fifteen feet.

Field Work

WEEDING. All fields were weeded regularly as follows:

Clean-cleared fields on the flat part of the Station every four months.

Mature areas under natural cover every three months.

Immature fields under natural cover every second month.

Nurseries and a few small areas every month.

All lalang was either dug out or destroyed with sodium arsenite.

A few patches of heavy bracken in Fields 19 and 24 were destroyed by a single round of spraying with sodium arsenite.

COVER CROPS. Natural covers were slashed every six to eight months. The cost of slashing has fallen steadily as the covers have been brought under control and now range from \$1.00 to \$3.25 per acre in the densest parts of the no-burn clearings. The total area slashed was 354 acres mature rubber and 158 acres under immature rubber.

DRAINS. A total of 2,290 chains of drains was cleaned and maintained during the year.

BUNDS AND TERRACES. The bunds and terraces in Fields 27 and 34 were repaired.

THINNING OUT. The details of thinning out are tabulated below. The trees were cut off at about nine inches from the ground.

Field	Trees removed	Date	Cost per tree
31	31	January	\$0.30
34	1,392	February	0.25
44	134	April	0.20
38 A	16	July	0.15
38 B	249	October	0.15
38	1,070	December	0.15

Pests and Diseases

ROOT DISEASE. Collar inspection and treatment were continued throughout the year in the younger fields.

MATURE RUBBER. Area treated—482 acres.

Incidence of Disease per acre

Field	Cases	Treated	Removed	Remarks
34	1.04	0.57	0.47	2 rounds
23 A	0.50	0.20	0.30	"
35	2.64	1.79	0.85	"
5 A	1.50	0.50	1.00	"
15 A	0.33	0.11	0.22	"
27	0.90	0.64	0.26	"
28	0.25	0.25	—	1 round
29	0.25	—	0.25	"
30	0.65	0.55	0.10	"
31	0.70	0.58	0.12	"
32	1.24	0.94	0.30	"
33	0.58	0.44	0.14	"
44	1.27	0.91	0.36	"
6	1.48	0.61	0.87	"

Total Trees

	Cases	Treated	Removed
Fomes lignosus ..	89	62	27
Ganoderma pseudoferreum ..	98	52	46
Fomes noxius ..	50	34	16
Ustulina zonata ..	109	79	30
	346	227	119

IMMATURE AREAS. Area treated—157 acres.

Incidence of Disease per acre

Field	Cases	Treated	Removed	Remarks
45	1.80	0.90	0.90	2 rounds
42	3.81	1.72	2.09	"
17 C	0.50	0.17	0.33	"
43	2.77	1.45	1.32	"
33 A	0.40	0.40	—	1 round
38	1.63	1.22	0.41	"

Total Trees

	Cases	Treated	Removed
Fomes lignosus ..	125	71	54
Ganoderma pseudoferreum ..	19	14	5
Fomes noxius ..	35	22	13
Ustulina zonata ..	20	16	4
	199	123	76

TERMITES. Regular rounds of inspection and treatment were carried out, and 3,363 trees were treated during the year.

Treatments:—

- (1) Tin mine arsenic;
- (2) Cymag and Sodium Silicofluoride;
- (3) Perchloride of Mercury 1% solution.

PINK DISEASE. The 1,286 trees treated for this disease were mostly in the immature areas.

SULPHUR DUSTING. Three rounds of sulphur dusting were carried out, using the new motor duster. A small hand duster was used for young nurseries.

STORMBLOWN TREES. Forty-four trees were removed.

MANURING. Before the war the general programme on the Station, apart from special experimental areas, was to manure

the fields in alternate years. It was decided to continue this policy, and a two-years programme was drawn up. The following fields were manured during July and August:—

Field	Acres	Lb. per tree	Mixture	Method of application
Mature				
1 A	3	5	C	Forked in
2	30	5	A	Pockets
3	10	5	A	Forked in
4 A, C	12.5	5	A	Forked in
5	40	5	A	Trenches
14 C & D	40	5 cwt. p.ac.	A	Forked in
15	81	5	A	Forked in
16	35	5	A	Trenches
16 F	2	4½	A	Pockets
25	21.5	5	A	Pockets
18 A & B	49	5	A	Pockets
20 A	3	5	C	Forked in
Immature				
17 C (Repl.)	7	3½	C	Forked in
33 A	4.5	3½	C	Forked in
42	5	2½	C	Forked in
43	13	3	D	Forked in
45 A	5	2½	D	Forked in
45 B	5	2	D	Forked in

Three methods of application were adopted:

- (1) In trenches six inches to nine inches deep between the rows. (This cost about \$7.00 per acre);
- (2) In pockets along the rows. (Cost \$3.75 per acre).
- (3) Forking in strips between the rows. (Cost \$2.50 per acre).

Composition of Mixtures used

Fertiliser		Mixture A	Mixture C	Mixture D
Sulphate of Ammonia	..	65%	50%	55%
Christmas Island Rock Phosphate	..	20%	30%	35%
Muriate of Potash	..	15%	20%	10%
Analysis				
N	..	13.5%	10.3%	11.3%
P ₂ O ₅	..	7.5%	11.4%	13.3%
K ₂ O	..	9.0%	12.0%	6.0%

Crop

AREA IN TAPPING. The area in tapping increased from 591 acres in January to 1,011 acres in December. This represents 93 per cent. of the mature area.

CROP. The total crop harvested amounted to 874,223 lb., giving an average yield of just over 1,000 lb. per acre.

The estimated crop for the year was 850,000 lb.

ANALYSIS OF CROP

R.S.S.	..	..	766,759 lb.
Blanket crepe	..	..	35,817 „
Scrap	..	..	24,300 „
Cup lump	..	..	47,347 „
			874,223 lb.

TAPPING DAYS

	Normal tapping		Late or interfered tapping	Total tapping days	No tapping
Indians	..	285	35	320	45
Javanese	..	290	28	318	47
Chinese	..	287	17	304	61

RAINFALL Rain was recorded on 180 days. The total rainfall for the year was 103.94 inches.

TAPPING COST. The average cost for all nationalities was 9.52 cents per pound.

MANUFACTURE In January alterations were carried out to the F.E.Coy. 6-rolls sheeting battery; the first two sets of rollers were removed and replaced by one set of multifaced rollers. A new set of marking rollers was also fitted. The battery worked satisfactorily with the five sets of rollers.

The sheeting battery was driven by the old Ruston-Hornsby seventeen horse-power engine until November, when a new five horse-power Lister engine was installed.

The small creping battery, which was damaged in May, was repaired and continued to work satisfactorily for the rest of the year.

Two new aluminium coagulating tanks were purchased from Messrs. Diethelm & Co. and installed to deal with the increasing crop.

SMOKEHOUSES. The large tunnel smokehouse was in operation throughout the year. The furnace arch at the hot end had to be replaced and also the furnace door.

The sheet took an average of five days to dry.

The small tunnel smokehouse was also in operation for certain periods and continued to give satisfactory results.

The two temporary smokehouses and one small Devon type smokehouse were used only during periods of emergency.

BALING All sheet rubber was packed in 224-lb. bare-back bales, which were painted with the talc and tapioca mixture.

MANUFACTURING COSTS. Factory labour, machining, curing, packing, chemicals, firewood etc. :— 1.90 cts. per lb.

RUBBER SALES. All rubber was sold locally.

Grade	Lb.	Price per lb.
R.S.S. 1 & 2 ..	766,528	34.0 cents
Clippings ..	9,288	23.7 „
Blanket crepe ..	31,520	20.3 „
Scrap ..	26,193	16.7 „
Cup lump ..	55,789	13.8 „
	<u>889,318</u>	<u>31.76 cents</u>

Total income from sale of rubber: \$282,451.93.

Experimental

BOTANICAL DIVISION

Recording the yields commenced in the following fields on the dates shown:

Field	Date of recording	Date of planting or budding	Experiment
1 A	March	1935	Stock experiment.
4 C	April	1929	Stock-scion relationship.
10	March	1931	High budding experiment.
22 B	March	1934	Stock-scion relationship.
33 A	January	1940	Small-scale clone trial.
34	May	1940	Small-scale clone trial.
38 A	June	1941	Legitimate seedling trial.
38 B	July	1941	Large-scale clone trial.
44	May	1940	Small-scale clone trial.

Recording was by cup-coagulation on two good tapping days in every month.

Recording in Field 25 (6) ceased in July 1947.

BUDWOOD DISTRIBUTION

There was a great demand for budwood of the three recommended clones, R.R.I. 501, 506 and 512, and quantities

had to be limited to 20 yards per estate, and altogether 3,485 yards were supplied to estates. Budwood of clone 501 and of various proved clones were also supplied to Agricultural Stations for multiplication.

CLONAL SEED. About 17,000 seed were supplied to Agricultural Stations and smallholders.

RUBBER SEED FOR OIL EXTRACTION

In October 4-cwt. of rubber seed were sent to the Agricultural Department, Serdang, for husking, treatment and despatch to London for tests. Later a further 7,000 lb. (approximately 700,000 seed) were sent for oil extraction. Cost of collection was three cents per pound.

SOILS DIVISION

Manuring Experiments

Field 6, 40 acres. Planted 1928 with unselected seedlings. Tapping and recording of this manuring experiment continued throughout the year. The last application of manures was in 1940. It was intended to apply manures biennially but the war prevented this and no manuring was done till this year. Manures were applied during May and June in shallow trenches six inches to nine inches deep between the rows of trees.

Plot	Treatment	Fertiliser	Amount per tree
A	Control ..	No manure	—
B	Organic ..	Cattle manure	84 lb.
C	N.P.K. ..	{ Sulphate of ammonia C.I. rock phosphate Muriate of potash	2½ " 1 " 1 "
D	N. ..	Sulphate of ammonia	2½ "
E	N.P. ..	{ Sulphate of ammonia C.I. rock phosphate	2½ " 1 "
F	P.K. ..	{ C.I. rock phosphate Muriate of potash	1 " 1 "

Field 31, 39 acres. Planted 1935—budded 1937. A manurial trial on hilly land under natural covers was budded with clones Tj.1, B.D.5, P.B.86, B.84 and D.65. The last application of manures was in May 1940. This field was brought into tapping for the first time in August on the full-spiral, fourth-daily system.

Yields were recorded by cup coagulation twice a month. Manures were applied in July in pockets along the terraces.

Plot	Treatment	Fertiliser	Amount per tree
A	Control	No manure	
B	N.	Sulphate of ammonia	2½ lb.
C	N.K.	{ Sulphate of ammonia Muriate of potash	2½ „ ½ „
D	N.P.	{ Sulphate of ammonia C.I. rock phosphate	2½ „ 1 „
E	P.K.	{ C.I. rock phosphate Muriate of potash	1 „ ½ „
F	N.P.K.	{ Sulphate of ammonia C.I. rock phosphate Muriate of potash	2½ „ 1 „ ½ „

General

BUILDINGS. A new office was built on the site of the old one, which was burned down in 1942. Two new semi-detached bungalows for the junior staff were erected. The petrol and oil store was rebuilt beside the new office.

Extensive repairs were carried out to the hill bungalow, which was badly damaged during the occupation.

Four new blocks of lines were built. Each block has five sets of two-roomed lines with verandah and kitchen quarters. This is similar to one type already constructed on the Station, and is popular with the labour force.

WATER SUPPLY. The two old Lister engines continued to drive the two pumps. All water is pumped from a dam in the stream in Field 22.

ELECTRIC LIGHTING. All bungalows and lines were wired and the whole system overhauled in anticipation of the early delivery of the new engine and generator. A temporary system is at present in operation, using a secondhand generator driven by the seventeen horse-power Ruston Hornsby engine in the factory. A new lighting set has been ordered for the hill bungalow.

MAIN ROADS. Considerable quantities of laterite were put down on the hill road and repairs were undertaken.

FENCING A new barbed wire fence, 168 chains in length, was erected on both sides of the main road between Fields 39 and 31.

LABOUR. A big increase in the labour force can be recorded after the set-back caused by the strikes towards the end of 1946.

Check Roll Labour

		December 1947	December 1946
Men	..	129	77
Women	..	97	61
Children	..	48	24
		<u>274</u>	<u>162</u>

In addition there are 35 Javanese and 12 Chinese tappers on contract. Dependants (mostly Indians) total 91.

HEALTH There was a marked improvement in health during the year. Malaria cases showed a steady reduction, but scrub typhus cases, although few in number were on the increase.

		Treated in Hospital	Treated in Lines
Malaria	..	6	132
Scrub typhus	..	5	Nil
Other diseases	..	76	293
Confinements	..	11	6

There were seventeen births and three deaths, including two infants, during the year. All labourers were vaccinated against small pox in May.

ANTI-MALARIAL. Regular oiling rounds were carried out in the anti-malarial areas. All drains in these areas were maintained in good order.

VISITORS. One hundred and seven visitors were shown round the Station during the year.

STAFF

Manager	..	D. S. Thomson
Assistant Manager	..	R. F. Harley
Assistant	..	Vacant

Experiment Station Staff	Institute Staff
1 Chief Clerk	Botanical Division 6
1 Assistant Clerk	Soils „ 1
1 Junior Clerk	Pathological „ 1
1 Hospital Assistant	Chemical „ 1
1 Field Conductor	
2 Tapping Conductors	
1 Factory Assistant	

I wish to express my thanks to the staff for their assistance during the year.

COURSES OF INSTRUCTION. Refresher courses for Rubber Instructors were held in March and May. Ten Agricultural students from Serdang attended a ten-days course of instruction in March.

ACKNOWLEDGMENT. I have to thank Mr. Carmichael of Edinburgh Estate for his assistance in dealing with crepe samples of the various clones.

III. REPORT FOR THE YEAR 1948

Acreage

Planted 1928-1947	..	..	1,226.25 acres.
„ 1948 (including nursery 5 acres)			155.00 „
Total planted			1,381.25 „
Previously planted, now felled	..	..	18.00 „
Building site and roads	..	..	64.43 „
Reserve land—old	..	..	52.82 „
Reserve land—new (not surveyed)	..	..	445.00 „
Total area			1,961.50 acres.

Planted Area

Mature rubber	..	..	..	1,158.25 acres.
Immature rubber	..	..	..	33.50 „
New planting 1948	..	..	..	150.00 „
Nurseries	..	..	..	39.50 „
				1,381.25 acres.

Not included in the above statement:—

2 <i>Hevea spruceana</i> plots	..	..	10.00 acres.
Smallholders' Nursery area	..	..	192.00 „

NEW LAND. Approximately 600 acres of land lying to the north-east of the Experiment Station has been acquired but the land has not yet been surveyed. The jungle was felled during the Japanese occupation and part of it used for food crop cultivation. After the re-occupation further clearing was done by mechanical means and some of the land was used for food crops. It was later abandoned and allowed to grow up in lalang, grass and belukar.

New Clearing

Approximately 150 acres of the new area adjoining the Station were cleared and planted with stumps during October and November. (Planting distance 20 feet by 10 feet rectangular; 217 per acre). The land which is undulating with an area of rather swampy land lying to the east side, was under lalang, grass and belukar. Lalang areas were sprayed with sodium arsenite seven to eight times. The belukar was felled and rentises six feet wide and twenty feet apart were cleared through the area. Apart from an accidental burn the area was not burned.

Six feet wide strips were also cleared for the planting rows through the grass and lalang areas after spraying the latter.

As the area varied considerably, with large and small patches of lalang, and light and heavy belukar with and without lalang, the 'all-in' clearing costs are not representative of any one type of clearing. The following figures will, however, give some idea of the cost of the various works:

	Cost per acre
Felling belukar	\$13/- to \$15/-
Clearing 6 feet planting rows in belukar ..	\$ 50.00
Clearing 6 feet planting rows in grass and lalang	24.00
Eradication of lalang by spraying and hand-pulling	104.00
Eradication of lalang by forking in swampy areas	180.00
Lining	5.00
Clearing around pegs in belukar areas ..	5.00
Holing—1 foot cube	11.00
Planting	3.50
Draining	18.00
Weeding (3 rounds)	14.50
Manuring	4.20

The total amount spent on lalang eradication over the whole area was \$86.00 per acre. It should be noted that the lalang areas were not all 'sheet' lalang and that work still remains to be done in some sections before eradication is complete.

Total expenditure per acre (all items) for first year—\$165.00.

Field work

WEEDING. Regular weeding rounds were carried out at intervals of one to four months.

LALANG. Lalang patrols kept this weed in check in all areas which were upkeep.

DRAINS. Seven hundred and twenty chains of main drain and 1,573 chains of field drain were cleaned out.

COVERS. All areas under natural covers were slashed back to three feet at intervals of six to eight months. Total acreage slashed during the year:

Mature area	..	..	..	805.75 acres.
Immature area	..	..	..	484.75 „

Costs varied from \$1.00 per acre in the light cover areas to \$3.25 in the dense cover fields.

BUNDS AND TERRACES. Bunds and terraces were repaired in Fields 27, 32, 33 and 35.

THINNING OUT

Field 38	..	..	..	751 trees removed.
„ 17C (Replanted)	..	..	151 „	„

Pests and Diseases

ROOT DISEASE. Tree-to-tree inspection was continued only in the younger areas. In the other fields inspection was confined to old diseased patches and their vicinity.

As no root disease work had been done in the older fields for some years a number of dead trees had to be removed and the area dug over.

Summary of Treatment

MATURE AREAS

		Area Treated	Total Cases	Trees Treated	Trees Removed
Collar inspection	..	189 acres	176	118	58
Diseased areas only	..	969 „	822	294	528
		1,158 „	998	412	586

Total Trees

		Cases	Trees treated	Trees removed
Fomes lignosus	..	181	103	78
Ganoderma pseudoferreum	..	190	98	92
Fomes noxius	..	255	139	116
Ustulina zonata	..	350	67	283
Sphaerostilbe repens	..	21	4	17
Unidentified	..	1	1	—
		998	412	586

IMMATURE AREAS

	Area Treated	Total Cases	Trees Treated	Trees Removed
Collar inspection ..	79 acres.	75	53	22

Total Trees

	Cases	Trees treated	Trees removed
Fomes lignosus ..	62	46	16
Ganoderma pseudoferreum ..	1	—	1
Fomes noxius ..	6	3	3
Ustulina zonata ..	3	1	2
Unidentified ..	3	3	—
	<u>75</u>	<u>53</u>	<u>22</u>

TERMITES. In the tapped areas attacks were reported by tapping kanganies. In other areas regular rounds of inspection were made. A total of 2,100 cases was treated in the mature rubber area, and 363 in the immature area.

TREATMENT. One per cent. solution of perchloride of mercury. PINK DISEASE. One round of inspection and treatment was made in Field 38 and two rounds in all the other immature fields.

STORMBLOWN TREES. One hundred and thirteen trees were removed.

MANURING. In continuation of the biennial manuring programme, the following fields were manured during July and August:—

Field	Acres	Lb. per tree	Mixture
5 A	2	4	A
10	8.50	5	A
14E.1, 2 & F	20	5	A
15 A	10	4	B
21	23.25	5	A
22	17.50	5	A
25 (5)	14	5	B
26	10	4	B
28	4	3½	B
29	4	3½	B
30	41	4	B

METHOD OF APPLICATION. All manures were applied in pockets along the rows or terraces—about twelve per tree.

	Manure	Application
Cost per acre ..	\$44/- to \$46/-	\$3.90 to \$4.50

Composition and Analysis of Manures Used

Fertiliser		Mixture A	Mixture B
Sulphate of Ammonia	..	60	63
Algerian Rock Phosphate	..	28	32
Muriate of Potash	..	12	5
Analysis			
N	..	12.4%	13.0%
P ₂ O ₅	..	7.0%	8.0%
K ₂ O	..	7.2%	3.0%

Crop

TAPPING. The area in tapping was increased by 123 acres during the year to 1,130 acres. This represents 97 per cent. of the mature rubber area. The resting area is being reserved for special experiments.

Tapping Tasks

		1st day	2nd day	Total
Indians	..	120	118	240
Javanese	..	35	35	70
Chinese	..	12	12	24
		<u>167</u>	<u>165</u>	<u>334</u>

TAPPING DAYS

		Normal tapping	Late or interfered	Total	No tapping
Indians	..	297	30	327	39
Javanese	..	302	16	318	48
Chinese	..	299	12	311	55

RAINFALL. Rain was recorded on 163 days. Total rainfall for the year was 95.42 inches.

TAPPING COSTS. The average for all nationalities was 10.37 cents per pound.

CROP. The total crop harvested amounted to 1,092,275 lb., giving an average of 968 lb. per acre for the year for the total area. The actual yield per acre for the areas tapped throughout the year was slightly higher. The estimated crop for the year was 960,000 lb.

Crop manufactured

Grade	lb.	Percentage
Smoked sheet ..	921,905	84.4
Blanket crepe ..	36,942	3.4
Scrap ..	54,350	5.0
Cup lump ..	79,078	7.2
	<u>1,092,275</u>	<u>100.0</u>

MACHINERY. The Federated Engineering Company's sheeting battery, driven by the five horse-power Lister engine, continued to work satisfactorily throughout the year. Some repairs were necessary to the roller bearings.

The rollers of the small creping battery were much worn and temporary repairs were effected.

The seventeen horse-power Ruston-Hornsby engine which drives the creping battery and lighting set was overhauled.

SMOKEHOUSES. The large Tunnel smokehouse was in operation throughout the year. A new furnace arch and door had to be fitted to the hot end.

The small Tunnel smokehouse and the temporary smokehouse were in operation at various times.

NEW EQUIPMENT. One new all-aluminium coagulating tank and one Aglo baling press were installed to deal with the increasing crop.

MANUFACTURING COSTS were 1.70 cents per pound including machining, curing and baling, firewood and chemicals.

RUBBER SALES. All rubber was sold to local dealers. Total sales for the year were:—

Grade	Lb.	Average price per lb.
R.S.S. No. 1 ..	838,880	39.0 cents
R.S.S. No. 2 ..	61,824	37.8 "
Clippings ..	7,576	27.1 "
Blanket crepe ..	40,250	22.8 "
Scrap ..	55,000	13.8 "
Cup lump ..	72,000	13.6 "
	<u>1,075,530</u>	<u>35.3 cents</u>

In addition 3,199 lb. of rubber were sent to the Institute for experimental purposes.

Total income from sales of rubber:—\$380,693.05.

Experimental

BOTANICAL DIVISION

Tapping and recording the yields was started in the following fields:—

Field	Date of tapping	Date of planting or budding	Experiment
18 A & B ..	January	1932	Tapping Experiment.
21 ..	March	1931	Tapping Experiment.
27 ..	January	1934-36	Cover crop Experiment.
28 & 29 ..	January	1936	Stock Experiment.
35 ..	May	1937-39	Jungle poisoning Experiment.
38 ..	May	1941	Small-scale clone trial.
43 ..	August	1941	Stock Experiment.
45 A ..	May	1942	Legitimate seedling trial.

BUDWOOD DISTRIBUTION. There was a considerable demand for budwood of the R.R.I. clones and quantities had to be limited until the new crops were ready for cutting. Totals of 7,398 yards were supplied to estates and 2,875 to Agricultural Stations. In addition, 12,245 yards of other well-known clones were supplied to Agricultural Stations and smallholders.

CLONAL SEED. Thirty seven thousand clonal seeds were supplied to Agricultural Stations and smallholders. Over half a million clonal seed were collected on the Station for the Smallholders' Nurseries on the Experiment Station.

NEW NURSERIES. About nine acres of land surrounding Jungle Plot B (now in the 1948 clearing) were prepared for new nurseries and seven acres were planted by the end of the year. One section is planted with seeds from Jungle Plot B, which contains *Hevea spruceana* and *H. braziliensis*.

SOILS DIVISION

Field 46 control of lalang after planting. Two-and-a-quarter acres of land under sheet lalang were planted with clonal seedlings of Tj.1 in November 1947. The cost and effectiveness of destroying the lalang by spraying, chipping and changkolling are being compared.

Nursery Manuring Experiment. A manuring experiment was laid down in one of the new nurseries planted during the year. Comparisons are made between various manurial treatments applied before and after planting.

PATHOLOGICAL DIVISION

Sulphur-dusting experiments were undertaken on clone B.D.5 in Field 19.

Tapping panels were sprayed experimentally in Fields 8 and 9.

In Field 36 nursery dusting experiments for control of *Helminthosporium heveae* were continued.

A new nursery is being prepared near Jungle Plot B for experimental work.

CHEMICAL DIVISION

Part of the old bucket store was fitted up as a Chemical laboratory. Some work on fresh latex can now be carried out on the Station.

Investigations were made on clonal latex and on latex from individual seedling trees possessing special properties.

A latex-clarifying plant was installed in the factory and was used for experimental work.

Experiments are being carried out to improve the shape of the bales by using various shapes of boards in the press. Early results are promising.

General

BUILDINGS. One large semi-detached bungalow and one small semi-detached bungalow were built for the junior staff. The hostel was repaired and two more rooms were added. The guest-house garage and syce's quarters and the Botanical Division germination shed were re-built.

NEW LINES. Two sets of five-roomed (double) lines were added during the year.

LINES UPKEEP. The main drainage system was relaid, using larger inverts. Lines, bath-places and latrines were repaired.

WATER SUPPLY. A new galvanised iron tank, a pipe line, pump and motor were installed at the hill bungalow.

One of the old pumps in the pump house was replaced by a new Goodwin pump.

An additional pipe line was laid to the lines.

ELECTRIC LIGHTING. The new Lister engine ordered for this year was not delivered and the temporary system continued in operation during the year.

A Southern Cross engine and lighting set were installed at the hill bungalow.

ROADS. Routine repairs and laying of laterite were undertaken.

FENCING. Sixty-four chains of barbed wire fence were erected along the main roadside.

ANTI-MALARIAL WORK. Regular oiling rounds were made and all drains in the area cleaned out. Concrete bunds were erected in Field 35.

UPKEEP OF BUILDING SITE. An Allen motor scythe was purchased and was of considerable use in keeping the grass areas under control.

LABOUR. The labour force steadily increased during the year, mainly owing to the return of many who left during the strike in 1946. There were no serious labour troubles of any kind and no days were lost on account of strikes. There was plenty to do and the labour force did good work in carrying out the full programme and harvesting the biggest crop of rubber ever obtained on the Station in spite of the emergency conditions.

CHECK ROLL LABOUR

		December 1948	December 1947
Men	..	156	129
Women	..	128	97
Children	..	38	48
		322	274
Dependants	..	157	91

In addition there are 35 Javanese and 12 Chinese contract tappers.

WAGE RATES. Wages were increased from 1st April 1948 and the minimum rates are now as under:

		Basic	C.o.l.a.	Total
Men	..	90 cts.	55 cts.	\$1.45
Women	..	70 cts.	45 cts.	\$1.15

In addition to the above tappers may earn up to 70 cents per day in the form of bonus.

HEALTH. The health of the labour force was good and there were no serious outbreaks of any disease.

	Admitted to Hospital	Treated in Lines
Malaria ..	1	12
Scrub Typhus ..	4	—
Injuries ..	1	87
Syphilis ..	1	—
Other diseases ..	84	407
Confinements ..	5	4

There were nine births and one woman and two children died.

	Men	Women
Spleen rate November 1948	4.7%	3.0%

VISITORS. Two hundred and fifteen visitors were shown round the Station during the year.

COURSES OF INSTRUCTION. Refresher courses were held for Rubber Instructors during February, March and April.

EMERGENCY. In common with other estates in the district it was necessary to take precautionary measures against attacks by terrorists.

STAFF

Manager	D. S. Thomson
Assistant Manager	R. F. Harley
Assistant	A. E. Browne

Experiment Station Staff

Office ..	3
Field ..	3
Factory ..	1
Hospital ..	1

Institute Staff

Botanical Division	6
Soils ..	1
Pathological ..	1
Chemical ..	1

Mr. A. E. Browne was appointed Assistant and assumed duty on 1st February. Mr. R. F. Harley was on long leave from April to November.

I wish to express my appreciation of the work of the staff in a year made difficult by the incidence of leave and the emergency conditions.

D. S. THOMSON

Manager

SUNGEI BULOH,

2nd February 1949.

REPORT FOR THE PERIOD SEPTEMBER 1945 TO DECEMBER 1948

SMALLHOLDERS' ADVISORY SERVICE

I. SEPTEMBER TO DECEMBER 1945

GENERAL

On the re-occupation of Malaya in September 1945 the need for the Smallholders' Advisory Service to assist the smallholders in re-opening their holdings and bringing them into production as quickly as possible was early realised.

Mr. Diaz, who was available at headquarters, assisted in the restoration of the service. All Rubber Instructors who were on duty at the time of the fall of Malaya were invited to return to their former stations. Of the forty Instructors who were available, only two failed to report but three others resigned before the end of the year. One new appointment was made and an Indian laboratory assistant was transferred from the Botanical Division to the Smallholders' Advisory Service.

At the end of 1945 there were, therefore, thirty-seven Rubber Instructors comprising twenty-three Malays, nine Chinese and five Indians. Ten Rubber Demonstrators were appointed during this period.

As far as possible Rubber Instructors were posted to their pre-war stations since familiarity with the district and the people was of obvious value. Certain adjustments were necessitated however by the difficulty of obtaining accommodation in some districts.

POLICY

Close co-operation with the Rubber and Produce Buying Unit was achieved. The local knowledge of Rubber Instructors was of value to the Rubber Buying Unit in effecting a fair distribution of such essential utensils and implements as were available. They were also in a position to supply information to the Rubber Buying Unit on local requirements. Broadly speaking the duties of Rubber Instructors during the latter part of 1945 were the encouragement of the maximum production of rubber by smallholders, and proper utilization of available materials.

With formic and acetic acids scarce or unobtainable, attention had to be directed to the use of substitute coagulants such as fermented toddy, coconut and tapioca water and tamarind leaves. Tests and demonstrations were carried out with these substances.

ULU KLANG AND AMPANG ROAD HOLDINGS

Work on the removal of lalang and the control of belukar was commenced with the limited labour force available.

II. REPORT FOR THE YEAR 1946

SUPERVISION AND ORGANISATION

Mr. Diaz continued his work in Kuala Lumpur until the end of March when he proceeded on long leave.

On his return from leave in April, Mr. Akhurst (Head of the Soils Division) undertook the supervision of the Smallholders' Advisory Service in addition to his other duties and continued to act as Smallholders' Advisory Officer until the writer was appointed to the post on 1st October. The writer has to thank his predecessors for their efforts in maintaining and reorganising the Smallholders' Advisory Service during a difficult period.

With the limited amount of time available for supervision by senior officers throughout the year, the difficulties of transport and the heavy demands of office work, visits to Rubber Instructors in the field were necessarily few. The following visits were, however, paid by Mr. Akhurst and the writer.

State	No. of visits to R.Is.	
	Mr. Akhurst	S.H.A.O.
Singapore ..	1	1
Johore ..	3	5
Selangor ..	5	—
Penang & P.W. ..	1	—
Kedah ..	1	—
Perak ..	2	6
Pahang ..	1	2
Malacca ..	—	2
Negri Sembilan ..	—	4
Total ..	14	20

Some of the R.Is. have been visited twice on their stations and only seven have not received visits. Of these,

four are in the most distant stations in Kelantan, Trengganu and Kedah and others might have been included in tours but for their absence on leave.

Our thanks are due to the officers of the Agricultural Department who have carried out the day-to-day supervision of the Rubber Instructors.

Rubber Instructors (R.Is.)

The service suffered a loss by the unfortunate death of Che Abdul Kadir in a river accident at Temerloh.

One Chinese Instructor resigned during the year and the total number of R.Is. at 31st December 1946 was thirty-five. The acreages which these men are attempting to cover are in almost all cases too high for efficient work, but it was found impossible during 1946 to make any new appointments, since the School of Agriculture, from which Rubber Instructors are normally recruited after graduation, was closed during the period of the occupation. A secondary factor which has prevented one or two possible appointments being made is the shortage of houses in the districts where R.Is. are most required.

At the re-occupation of Malaya the majority of R.Is. were overdue for leave. It was decided that from September, groups of R.Is. should be granted leave according to a roster which provided for the completion of all leave due by the end of 1948.

The distribution of Rubber Instructors and Rubber Demonstrators is shown in Table I. The acreage of small-holdings (under 100 acres) are taken from the 1940 figures which are the latest complete figures published. The average acreage served by R.Is. is calculated from these figures but since R.Is., particularly the Chinese and Indians, sometimes advise the small Asiatic-owned estates of over 100 acres the average acreage covered by each R.I. may be slightly greater than that shown in the final column.

Rubber Demonstrators (R.Ds.)

Experience before the war of the employment of R.Ds. encouraged an increased employment of suitable men and the number of R.Ds. was raised during 1946 from ten to twenty-three.

TABLE I *Distribution of Rubber Instructors and Rubber Demonstrators at 31st December, 1946*

State or Territory	Area of Smallholdings	Instructors			Demonstrators	Average area of Smallholdings per R.I.
		Malay	Chinese	Indian		
Perak	274,366	2	2	1	5	54,673
Selangor	145,017	3	—	1	4	36,254
Negri Sembilan	103,965	2	—	1	3	34,655
Pahang	96,777	1	1	—	2	48,388
Malacca	73,571	1	—	—	1	73,571
Province Wellesley	23,824	—	1	—	1	38,963 (i)
Penang	15,139	Served by P.W. R.I.			1	131,589
Labuan	1,886	Served by Brunei R.I.				
Johore	394,766	3	—	—	3	37,344 (ii)
Kedah	108,387	3	—	—	3	61,489
Perlis	3,646	Served by Kedah R.I.				
Kelantan	61,489	1	—	—	1	28,844
Trengganu	28,844	1	—	—	1	21,153 (iii)
Brunei	8,298	—	—	—	—	
Singapore	21,153	—	1	—	1	54,445
Total Malaya	1,361,128	17	5	3	25	
R.R.I.		—	—	1	1	
Experiment Station		—	—	—	—	
Leave		5	3	1	9	
Total		22	8	5	35	23

Notes

- (i) Includes Penang. (ii) Includes Perlis. (iii) This R.I. works also in S. Johore.
- Indian owners in Malacca may be advised by the Indian Rubber Instructor stationed in N.S.
- Areas of Smallholdings are taken from "The Malayan Agricultural Journal" Vol. 29, No. 7, July 1941.

Demonstrators were first employed to drive home the lessons of sheet production by constant repetition in the kampongs, but they have also been taught soil conservation methods, cabinet-type smokehouse construction and budgrafting. This latter work is likely to be of particular importance in the future.

The training of R.Ds. has been in the hands of the R.Is. under whom they work but it is hoped to increase their usefulness by giving them a course of training at the R.R.I. Experiment Station when facilities are available.

CONDITIONS ON SMALLHOLDINGS

The belukar which grew up in most rubber areas during the Japanese occupation is slowly being cleared in the mature areas on smallholdings. In the young areas planted in 1940 and 1941 there is less incentive to carry out the necessary work as this rubber is often very backward and there is no prospect of immediate revenue from it.

In coastal districts a notable result of the years of neglect of essential services during the occupation is the permanently flooded condition of much of the rubber land. The rubber trees are seriously, and probably in many cases permanently, affected by the stagnant water. Nothing can be achieved by owners since the cause is nearly always the silting up of main outlet drains which may be considerable distances from the flooded holdings.

Since most of the smallholders have insufficient money to carry out all the work that is desirable, the advice tendered has to be suited to their finances.

TAPPING

There was a steady increase throughout the year in the area in tapping. Figures submitted from various districts at the end of the year show that from 70 to 90 per cent. of the mature rubber areas were in tapping, but too much reliance cannot be placed on these figures since our facilities for collecting the necessary information are inadequate.

Owner-tapping, where practised, is of a high standard, but Malay holders with insufficient capital to undertake the tapping of their holdings frequently lease their land to tapping contractors, and since the owners exercise practically no control detrimental tapping invariably follows. On the expiry of the lease the rubber has usually much depreciated in value.

A few areas of pre-war buddings are now in tapping on smallholdings. These commonly belong to Chinese and Indians, but some are owned by Malays, and in all cases owners appear to be fully aware of the value of their trees and have adopted conservative tapping systems.

COAGULANTS

In the early part of the year instruction in the use of home-made coagulants such as fermented tapioca water, coconut water and toddy had to be continued. Later, when formic acid commenced to arrive in the country, much of the R.Is. time was devoted to the allotment and distribution of supplies to smallholders. This was a very necessary service to ensure that smallholders received a fair share of good acid at a reasonable price, and this purpose appears to have been achieved. The work however made heavy demands on R.Is.' time at the expense of their normal duties, and the arrival of adequate supplies which will relieve R.Is. of this work will be welcomed.

SHEET PRODUCTION

As was to be expected with the high demand for rubber, improvised utensils and a high proportion of inferior coagulants, the quality of smallholders' sheet has deteriorated. The break in practice and instruction has also had its effect, and smallholders are probably now more careless of elementary precautions in sheet manufacture than they were before the war. Old worn sieves and home-made substitutes using ijok fibre or lalang result in dirty sheet. Common faults are too thick sheet and surface mould. The former can be attributed to shortage or high price of coagulating pans which results in insufficient dilution of the latex, and the latter is frequently the result of failure to use sufficient washing water during manufacture.

With the extension of areas in tapping and the resulting revenue to smallholders, coagulating and machining sheds are being erected on many holdings. The importance of adequate water supplies in the siting of these sheds is emphasised.

The bulk of smallholders' rubber is sold unsmoked and frequently with a high water-content. The Malay smallholder remains indifferent to the profit to be made from smoking his own sheet. Smoke-houses have been built, mainly by the medium holders, of anything from 5-40 piculs capacity. There has been little inclination on the part of kampong people to

build cabinet-type smoke-houses and central Pahang, where suitable materials are relatively cheap, is the only district in the writer's experience where much development of this type of smoke-house can be expected.

Co-operative schemes for smoking seem to be the most promising means of inducing the Malay smallholder to produce smoked sheet, but intensive propaganda, education and tact are required in initiating such systems.

REPLANTING

Very little replanting appears to have been done on smallholdings during 1946, and that which has been done is generally on food-crop areas where rubber was removed during the Japanese occupation. In some of these areas owners have planted rubber stumps amongst crops. Attention will have to be given to the manuring and budgrafting of these trees during 1947.

Smallholders are not prepared to embark on the felling and replanting of present stands of rubber until they feel assured of some source of revenue to carry them over the years till the young rubber will be tappable. They are interested in the possibility of the re-introduction of restriction which in pre-war years provided them with income from the sale of coupons.

Figures supplied by the Office of the Controller of Rubber, Malayan Union, show that during 1946 there were 119 applications for permission to replant, covering a total of 842 acres on holdings of less than 100 acres.

PESTS AND DISEASES

Mouldy rot did serious damage on smallholdings during the last quarter of 1946. This was to be expected during the wet season on account of the dense growths of belukar commonly found in kampong rubber since the occupation.

Fungicides which have been available are all of the water-miscible type, and the daily application which is necessary to secure control with these is not popular with typical smallholders.

Efforts of R.Is. have been directed to discouraging the use of substances such as tar, which can be harmful to bark, and encouraging the application of approved fungicides.

Pink disease has been found in many of the young rubber areas but the owners are generally prompt to act on advice given, and control of this disease has usually been satisfactory.

As a result of neglect during the occupation years termites have done, and continue to inflict, heavy damage. Lack of suitable materials for their control has made it difficult to recommend a satisfactory treatment. Supplies of Cymag and sodium silico-fluoride, which are becoming available, will make it possible for more satisfactory action to be taken during 1947.

Root diseases do not appear to have increased noticeably in mature rubber areas and smallholders tend to accept such infections as permanent features of their holdings. It is pleasing to note that owners of pre-war replantings and new plantings are more conscious of the dangers from root disease and would be anxious to take the necessary steps for control were labour and materials not so expensive. There is no doubt that it is to such areas and future replantings that advice must be principally directed.

RUBBER MANGLES

Large stocks of rubber mangles suitable for use on smallholdings were imported by the Rubber Buying Unit. The Institute has assisted in the collection of orders through R.Is., and has provided storage space for a large number of mangles. The demand for these mangles at the present time appears to have been met, and few sales have been reported latterly.

SHOWS

Exhibits at Mukim and District Agricultural shows have been arranged by R.Is. and attention has been concentrated on proper methods of sheet production.

The Institute's exhibit at the Malayan Agri-Horticultural Exhibition in Kuala Lumpur was arranged primarily to appeal to the smallholders. Proper utensils, grades of rubber and a cabinet-type smoke-house were displayed together with R.R.I. Publications.

SMALLHOLDERS' RUBBER ADVISORY COMMITTEE

The fourth and fifth meetings of the above committee were held during the last quarter in 1946. Important aspects of future development of the Smallholders' Advisory Service were considered, and particular attention was given to the present day needs and difficulties confronting the smallholder in bringing his rubber back into production. The possibilities of large-scale replanting and the provision of adequate supplies of improved planting material were also discussed.

VISIT BY MR. P. T. BAUER

During August and September, Mr. Bauer visited Malaya at the invitation of the Colonial Office to report on the conditions prevailing on smallholders' rubber areas.

All possible assistance was given to Mr. Bauer to render his survey as complete as possible. An extensive tour of the whole country with the exception of the East coast was arranged, and since Mr. Bauer had no previous knowledge of the country or its languages, R.Is. in the various districts visited acted as guides and interpreters for him.

CONCLUSION

The Smallholders' Advisory Service is now below its maximum strength of December 1941, when it was still an expanding organisation and inadequate for the task with which it had to deal. The full complement then aimed at was fifty Rubber Instructors, but whether this figure will be sufficient to carry out fully the functions of the Service, remains to be seen. It seems unlikely that there will be sufficient suitably trained men available during the next two years to bring the number of Instructors up to fifty.

Every effort will be made to secure the maximum development of the Service. With the limited staff anticipated the maximum efficiency of each individual is essential. Greater numbers of R.Ds. can effectively extend the range of a R.I. and further training of the former might fit them for greater responsibility. Lack of private transport has seriously limited the working area of each R.I. and it is hoped that it will soon be possible to obtain light cars for the majority.

It has always been intended that contact between the Institute and the R.Is. should be maintained as closely as possible. In 1941 with a full-time Smallholders' Advisory Officer and the Personal Assistant to the Director devoting part of his time to the supervision of the service, it was apparent that supervision might be insufficient for the expanding service. Supervision must still be considered as below requirements and consideration is being given to the revival of the scheme for promotion of a limited number of Superintendent Instructors on the lines of the trial scheme in operation in 1940 and 1941.

III. REPORT FOR THE YEAR 1947

Supervision and Organisation

The demands of office work concerned with the administration and development of the service have severely limited the time which the writer has been able to spend in visiting Rubber Instructors and in assisting with individual advisory problems. The need for increased strength at headquarters in order to co-ordinate effectively the service for the whole country is still apparent, and provision has been made for the appointment of an Assistant Smallholders' Advisory Officer in 1948.

Our aim during the year has been to maintain the standard of service for the smallholder which had been achieved before the war, and to prepare for expansion when sufficient numbers of properly trained Instructors become available. This will not be before 1949 when the first post-war class from the College of Agriculture completes the major course. Our effective range however has been extended steadily during 1947 by the gradual allotment of light cars to Rubber Instructors and the general position of transport must be considered satisfactory at the end of the year.

The writer's visits to Rubber Instructors in the field are summarised in the following table:

Quarter	State, Territory or District	Visits to Instructors	Number of days
First ..	Selangor ..	5	5
	Perak ..	2	3
	Penang and Province ..		
	Wellesley ..	1	2
	Kedah ..	3	4
Second ..	Selangor ..	3	2
	Pahang ..	1	2
	Perak ..	3	4
	Johore ..	4	6
Third ..	Kelantan, Trengganu and East Pahang ..	3	14
Fourth ..	Perak ..	6	5
	Penang and Province ..		
	Wellesley ..	1	1
	Kedah ..	1	1
	Selangor ..	2	1
		35	50

SUPERINTENDENT RUBBER INSTRUCTORS

A scheme for local supervision of Rubber Instructors on all technical matters was inaugurated on 1st July with the promotion of three senior Rubber Instructors to the newly-created post of Superintendent Rubber Instructor.

This scheme at present covers three districts; Perak, a central section comprising Selangor, Negri Sembilan and Malacca, and Johore. These districts contain over 70 per cent. of the smallholding rubber of the country and a corresponding proportion of our present strength of Rubber Instructors is stationed in them. The system can be extended to cover other parts of the country when increases in staff justify such development.

Superintendent Rubber Instructors are responsible for supervising the work of all Rubber Instructors in their districts. They advise and assist them on all technical matters with the aim of securing uniformity in the dissemination of information on rubber-growing problems. They maintain contact with districts where it has not been possible to station Rubber Instructors and co-ordinate the collection of data on smallholdings throughout their areas. The information which S.R.Is. are able to furnish is of considerable assistance to the Institute in planning future development.

S.R.Is. do not have any administrative responsibilities and control of the service throughout the country will remain centralised at headquarters. Correspondence on such subjects as salaries, allowances, expenses and leave is maintained direct with Rubber Instructors through the appropriate officers of the Department of Agriculture.

With the introduction of the Superintendent Rubber Instructor scheme the method of compiling monthly reports was simplified for Instructors by the introduction of a set form of monthly statement. This requires merely the correct abstraction of details of certain aspects of planting, tapping and disease which are recorded daily in Rubber Instructors' diaries.

RUBBER INSTRUCTORS

Three senior Rubber Instructors were promoted Superintendent Rubber Instructors:—

Mr. G. Diaz—Selangor, Negri Sembilan and Malacca.
Che Hussein bin H. Alang Samsudin—Perak.

Che Mohamed Aris bin Ahmad Fathil—Johore.

It is with regret that we record the death of our former Chinese Rubber Instructor in Segamat.

During the year an Indian Rubber Instructor on prolonged extended leave of absence was finally considered to have resigned. This Instructor had not been an effective member of the staff since the liberation of Malaya. In addition one Chinese and one Malay Instructor resigned during the year.

Our losses have been more than offset by the appointment of six new Rubber Instructors—one Malay, four Chinese and one Indian. Five of these men are pre-war graduates of the College of Agriculture and one has completed his diploma course since the liberation.

During the year 21 Rubber Instructors were on leave for periods varying from one to five months giving a total of approximately 70 "leave months" for the whole service. All outstanding accumulations of leave should be taken by the end of 1948 after which we may expect at least two years of work at full strength.

The total numbers of Rubber Instructors and Rubber Demonstrators and their distribution are shown in Table II.

TRAINING

The newly-appointed Rubber Instructors all received courses of training at the R.R.I. Experiment Station. Courses varied in length according to the facilities available at the time, and the previous field experience of the Instructor. The new men went to their first stations only after being attached for instruction in routine duties to more experienced Instructors.

During the year all Instructors appointed before 1946 have had an opportunity to return to the Experiment Station for an intensive "refresher" course lasting one week. Five such courses were required to accommodate the 32 Instructors who have attended.

RUBBER DEMONSTRATORS

In the more remote areas the most important job of the Rubber Demonstrators remains instruction in the manufacture of clean sheet. In districts where new planting and replanting are commencing on smallholdings demonstration and assistance in budgrafting become of greater importance to the smallholder. Training of Demonstrators has been directed to meeting this requirement and vacancies have been filled and new appointments made with the same object in view.

TABLE II. *Distribution of Field Staff as at 31st December, 1947*

State or Territory	Area of Rubber* Smallholdings	Superintendent Rubber Instructors	Rubber Instructors			Demos- trators	Average acreage per Rubber Instructor
			Malay	Chinese	Indian	Total	
Perak	274,366	1	4	1	1	6	54,873
Selangor	145,017		3	1	—	4	36,254
Negri Sembilan	103,965	1	2	1	—	3	34,655
Malacca	73,571		1	1	—	2	36,785
Johore	394,766	1	1	3	—	4	98,692
Pahang	96,777		3	—	—	3	32,259
Kedah/Perlis	112,033		2	—	—	2	56,016
Kelantan	61,489		1	—	—	1	61,489
Trengganu	28,844		1	—	—	1	28,844
Penang & Prov- Wellesley	38,963		—	1	—	1	38,963
Singapore	21,153		—	—	—	—	
Leave	1,350,944	3	18	8	1	27	
Experiment Station			2	1	2	5	
			—	1	1	2	
Total		3	20	10	4	34	28

* Areas of Smallholding rubber are taken from the Rubber Statistics Handbook, 1946, which are the latest complete figures available.

The total number of Rubber Demonstrators at the end of 1947 was 28, an increase of six over 1946.

SMALLHOLDERS' RUBBER ADVISORY COMMITTEE

The sixth meeting of the Smallholders' Rubber Advisory Committee was held at the Institute on the 28th October. The general lines of future development of the Smallholders' Advisory Service were discussed together with the estimates of expenditure for 1948. Certain particular aspects of smallholding rubber production were also considered.

On the question of the possibilities of extending the area planted with improved material on smallholdings special attention was given to the land cleared of rubber during the period 1942-45. It was considered that these areas offered the best opportunity for encouraging replanting amongst smallholders. More information about such areas is required and when it is available the establishment of demonstration plots in suitable districts where the co-operation of a smallholder can be obtained, was recommended.

Provision of a supply of first-class planting material at cheap prices is a necessity if planting with good material is to be encouraged. Plans for the supply of budwood are satisfactory and expansion could rapidly be effected. The merits of proved clonal seed for use on smallholdings and the means for providing a cheap supply are receiving consideration.

The large loss to the smallholder community from their inability to undertake the smoking and organise the marketing of their rubber was considered, and provision has been made for investigation of the possibilities of building cheaply constructed smoke-houses to be run on a communal basis.

Field Work and Advisory Policy

TAPPING

It is difficult to obtain accurate figures of the area of smallholding rubber in tapping at any one time. Fluctuation in area, however, is not violent and there has been a small increase in the acreage opened for tapping during the year. Greater variations occur in the intensity of tapping and these are conditioned by the price of rubber, the seasonal needs of food production, alternative occupations, the general wage level and the weather. Smallholders' production figures normally reflect changes in intensity of tapping rather than changes in acreage tapped and figures for 1947 show that the smallholder

has been considerably influenced by the price of rubber in the amount of time he is prepared to devote to tapping.

Fluctuating intensity of production explains why smallholders have been able to maintain their system, nominally daily tapping, for periods beyond the reasonable expectation of those familiar exclusively with estate production methods. An important factor rather infrequently recognised is the common use on smallholdings of a tapping panel of less than half-circumference.

Little can now be achieved by advising smallholders on proper methods of tapping their old seedling rubber trees. Where bark consumption has been excessive it generally reflects the poverty or lack of economic independence of the owners, and future treatment will be dictated by economic circumstances and not by the advice of experts.

Response is good to advice on opening up and tapping pre-war replantings and new plantings on smallholdings but these rather limited areas are naturally in the hands of the most progressive section of the smallholder community.

COAGULANTS

Rubber Instructors have continued to assist in the distribution of controlled supplies of formic acid undertaken by the Department of Agriculture in collaboration with the importers. In the early part of the year this service had the valuable effect of bringing down the prices of locally bottled acids, mainly sulphuric, to a competitive figure. The price of these acids has remained fairly constant for the greater part of the year at figures which allow slightly cheaper coagulation than if formic or acetic acid is used. Quantities of mineral acids in the country are known to be large. For a given coagulating power the cost of sulphuric acid to the distributors is probably less than one-fifth of the cost of formic or acetic acids so that the trade in this would be more attractive to retailers even were supplies of formic and acetic acids adequate.

Consideration of the figures for the quantities of formic acid supplied through the Department of Agriculture in Selangor during a twelve-months period indicate that smallholders in the state have not had the opportunity to purchase through official channels sufficient acid to coagulate more than 20 per cent. of smallholding production. The alternative source of supply is from local shops and dealers stores and there is little opportunity for such suppliers to

obtain any appreciable quantities of the approved acids. This means that in Selangor a little less than 80 per cent. of smallholders rubber has been coagulated with sulphuric acid and it does not seem likely that the figure is lower in other parts of the country.

The distribution of sufficient acid to meet smallholders requirements would occupy an excessive part of the Rubber Instructors' time were the acid available. The significant point is, however, that smallholders are no longer very interested in formic acid. The price of sulphuric acid has been brought low enough to be attractive in comparison with formic acid at controlled price and it could no doubt be brought lower still. The smallholder prefers to buy his acid as he requires it and from a source which will provide credit. There is no doubt that at present prices the smallholder will continue to use sulphuric acid even if supplies of formic are plentiful, unless compelled to do otherwise.

In these circumstances the time which Rubber Instructors devote to the distribution of limited quantities of acid to a very limited clientele does not appear to be justified. The work was first undertaken at a time when supplies of all kinds of acid were very scarce in an attempt to ensure the most equitable distribution of the available acid and in an endeavour to prevent a lack of acid from checking the production of rubber by smallholders altogether. It is now clear that the time which Rubber Instructors spend on distributing inadequate amounts of coagulant to smallholders would be better employed in endeavouring to obtain the least harmful use of the coagulants which are easily available.

During July and August Rubber Instructors all over the country purchased representative selections of the coagulants on sale in their districts and forwarded them to the Institute with comments on the relative popularity of the different brands. These samples have been the basis for the survey of coagulant supplies conducted by the Chemical Division. The survey has indicated the complete dependence of the smallholder on his supplier. Popularity frequently bears no relationship to intrinsic value and analyses of different bottles of the same "chop" show that variation occurs within brands. Some legislation to protect the buyer by enforcing a declaration of contents seems to be very necessary not only in the interests of the small man but to protect the quality of Malayan rubber. It is essential to know the strength of the acid used in coagulation if the harmful effects of sulphuric acid on the quality of the rubber are to be avoided.

PREPARATION AND MARKETING

Difficulties encountered in securing improvement in the quality of sheet produced on smallholdings have not changed since before the war. Elimination of dirt and bubbles and production of thin sheet require only care and would be effected by many smallholders provided that there was sufficient incentive for them to do so. Grading and marketing schemes can provide this incentive if the co-operation of dealers can be secured and dealers stand to gain by a general improvement in quality. One such scheme was introduced in Ulu Selangor during 1947 and gives promise of some improvement in the general quality of the rubber in the district. The introduction of similar schemes has also been considered in Negri Sembilan and Kedah. Grading schemes however are only one means of improving smallholders' rubber and their appropriateness must be decided for each state or district by the men familiar with local conditions.

Certain common faults in smallholders' rubber in this country are caused by factors whose remedy requires extra labour or capital equipment beyond the individual smallholder's means. Rust and oxidation generally result from insufficient use of water during and after machining the sheet. Other causes are deteriorated equipment and insufficient protection from the weather for mangles. Smallholding rubber invariably suffers from too long delay, either in the smallholder's or dealer's hands, between machining and smoking. The partially dried, rather thick sheet develops a skin which makes complete drying virtually impossible. Oversmoked unsightly sheet results from attempts to cure such rubber properly. It seems necessary that smoking should be done by the smallholder both to safeguard the quality of his product and to ensure that he receives the proper reward for quality. Small smoke-houses are uneconomical to run and are not popular. Co-operation is the obvious remedy both to achieve smoking and to improve equipment and methods of manufacture.

The Smallholders' Advisory Service collaborates wherever possible with the Co-operative Societies Department to secure the extension of co-operative methods of production. The profits to be secured by co-operation in production and marketing have been amply demonstrated, but response to advice and propaganda is poor. This may be attributed to the individualism and improvidence of the Malay peasant.

During the year there have been reports from various centres of attempts to purchase liquid latex from smallholders.

These have been by firms interested in the export of liquid latex or the manufacture of sole crepe, and who are in a position to offer an attractive price. Actual prices have frequently been the equivalent of good quality unsmoked sheet on estimated d.r.c. and smallholders have had no expenses for coagulant or machining. There has however been no evidence that smallholders have been particularly anxious to maintain such an outlet for their produce nor the confidence of the buyers. Development of the liquid latex market deserves encouragement for it provides a profitable outlet for smallholders' rubber. It should also benefit the country as a whole by raising the standard of the rubber exported from at the best indifferent sheet to good quality latex or sole crepe.

CO-OPERATIVE SMOKE-HOUSES

In devising means for encouraging the establishment of co-operative smoke-houses in the kampongs the limited financial means of the *rayat* must receive primary consideration. There are difficulties in the way of operating a scheme of loans for this purpose and essentially there must be some proof of willingness on the part of participators to save, and to make a certain amount of effort to achieve their object.

Low capital cost is therefore necessary for any smoke-house that is to be built in the kampongs, and to achieve this it seems necessary to employ locally available materials for the fabric of the building. To test the possibility of co-operative organisations to smoke rubber, the State Agricultural Officer, Selangor, and the Co-operative Marketing Officer have collaborated with the writer to endeavour to secure the establishment of a small number of trial smoke-houses. A start was made with one smoke-house in Selangor during December and for this the structure is to consist essentially of split bamboo walls and atap roof lined with gunny and a 45-gallons drum furnace with trench flues covered with corrugated iron and sand. Other inexpensive materials will be tested for the fabric as opportunity offers. For these trial smoke-houses the Agricultural Department is providing the essential equipment which cannot be obtained locally by the people's own efforts. It is proposed to establish up to ten similar smoke-houses in widely distributed parts of Selangor in the hope that the example will encourage other kampongs to undertake unaided construction.

Though these smoke-houses are essentially of a temporary type they should last long enough to establish profits which

if properly utilized will more than provide for the replacement of the temporary structure by an improved type.

DISEASES AND PESTS

Proper treatment of diseases and pests is probably the most difficult subject on which to advise smallholders and the more slow acting the disease the less is the response to advice offered.

Little is done on smallholdings to control root disease and the one method which appears to have been learnt or copied from estates, is isolation by trenching. Trenches are normally dug only when the disease is apparent from the death of a tree and then the perimeter is so small that the method is invariably ineffective. Rubber Instructors are now concentrating their efforts on root disease control in replanted areas where their advice will give more valuable returns.

In pre-war replantings pink disease is now a frequent cause of considerable damage to the young rubber trees. Instruction must be supported by demonstration which demands time and considerable physical exertion. Special training of our Demonstrators in this subject will probably be well justified as young rubber areas on smallholdings increase.

Termites have been another cause of damage to young rubber. The neglect of such rubber during the war years and the resulting overgrown condition have permitted an increase of this pest which might have been prevented under more normal conditions of maintenance. Treatment with mercury perchloride has been encouraged by Rubber Instructors and assistance has been given to interested smallholders to obtain supplies of the chemical.

Mouldy rot has maintained its position as the principal disease on smallholdings and the difficulty of securing effective treatment remained as great as formerly. The availability of fungicides from Agricultural Offices has been a great help to smallholders wishing to carry out our recommendations, but the continued regular application of water-miscible fungicides, which is necessary to secure effective control, is a system which is unattractive to smallholders. In general the best that can be expected is a limitation of damage and not complete control. Smallholders prefer to apply a material which remains visible for a lengthy period, which explains the common use of mud, tar, cow dung, and oil mixtures and the popularity of relatively expensive fungicides containing dyes.

PLANTING OF RUBBER

When compared with the need for improvement of smallholding rubber areas the extent of planting and replanting on smallholdings up to the end of 1947 as shown by the available figures appears very disappointing. As a measure of increasing interest and ability to undertake planting they are, perhaps, more encouraging.

As a training ground for our service and for smallholders in the tasks which must be accomplished if smallholding rubber areas in this country are to provide the standard of living for their owners that is desired for them, the 4,000 acres of planting have been most useful.

Acreage figures for rubber planting on smallholdings which has been accomplished since the occupation under the observation of our Rubber Instructors are given in Table III. Also included in the table are figures supplied by the Registrar of Statistics of areas felled during the occupation years. Planted acreages quoted represent the minimum figures since we cannot claim to cover the country completely. They show clearly that replanting has rarely been attractive except when the old rubber had been previously removed. In the absence of new land alienation there has been practically no new planting by smallholders.

There is no doubt that there is considerable interest in the planting of rubber amongst smallholders. To what extent this interest is likely to result in the extension of young rubber areas on smallholdings is a matter of greater doubt, and is dependent on the manner in which the economic difficulties confronting the small man in establishing rubber and bringing it to maturity can be resolved. To plant young rubber trees a smallholder requires to feel assured of a source of income during the years before the rubber will be tappable. Possible sources of income for the peasant planter appear to be an alternative area of mature rubber in tapping, inter-cropping with food or catch-crops between the rows of young rubber, or work on land belonging to another. The last is not entirely suitable as such work probably makes too heavy demands on a smallholder's time to allow him to look after his own area properly. Inter-cropping allows harmful growths to be controlled and during the first three or four years will not, on flat lands, cause deterioration of soil or harm to the rubber provided reasonable cultivation practices are adopted and exhausting crops are avoided.

TABLE III. *Rubber Planting on Smallholdings (under 100 acres) since September 1945*

State or Settlement	Area of Smallholding * rubber felled during the enemy occupation	Replanting		New Planting
		Felled 1942-45	Felled since 1945	
Selangor ..	2,386	1,062	138	62
Negri Sembilan ..	151	15	114	—
Malacca ..	6,021	230	12	—
Perak ..	788	227	75	—
Johore ..	8,966	1,939	25	60
Pahang ..	37	11	15	—
Kedah and Perlis ..	1,905	126	30	—
Penang and Prov. Wellesley ..	3,157	147	—	—
Kelantan ..	3,067	—	—	—
Trengganu ..	—	—	—	—
	26,478	3,757	409	122

* Figures supplied by the Acting Registrar of Statistics, Federation of Malaya.

During 1947 the greatest area of young rubber has been established in North Johore on land where old rubber had been cut out during the Japanese occupation. This land is fairly flat and fertile and gives a good return on cultivation for food crops. The rubber might almost be said to have been planted as a secondary interest. The same process has also been observed in Selangor and Perak particularly on Chinese holdings.

It has not been possible during 1947 to observe the probable extent of new planting by smallholders since no new land has been alienated for rubber. Interest in new land however shows a disturbing tendency to fluctuate with the price of rubber and this does not augur well for the future maintenance of new rubber areas. Such rubber might be best safeguarded if peasant interests were spread over a wider field. Inter-cultivation of rubber areas with short-term crops is of great financial assistance but can only be permitted on flat or nearly flat land. A second tree crop would provide greater economic stability and on hilly land is the only alternative which consideration of soil conservation should permit.

It does not seem likely that there will be any extensive replanting of smallholdings except on land felled and cleared

during the occupation or on holdings near towns where a good price can be obtained for the old trees as firewood. Neither is there much incentive to replant derelict lalang areas, to which state much of the felled rubber has deteriorated. It is cheaper and more profitable to develop virgin land for rubber than to replant sheet lalang and the problem of future utilization of such areas is a difficult one. Almost one million acres of rubber in this country are composed of holdings containing under ten acres of rubber and a large proportion are under five acres. While it is technically possible to replant blocks of between one and two acres in old rubber areas without getting serious reduction in growth from shade and root competition, and smaller areas at intervals if a progressive replanting programme is intended, it is difficult to believe that the average smallholder could forego the necessary proportion of his present income or would sink further money or effort in his land for a somewhat insecure future reward.

If smallholding rubber lands are to maintain or improve their present competitive position with estate rubber it seems to be necessary that individual owners should obtain additional land. New land planted with modern material would provide the economic means for replanting existing areas after a lapse of seven years. Such a statement admittedly over-simplifies the problem of resolving the smallholders' replanting difficulties. Suitable land must be found reasonably close to existing holdings and this is not always available. The smallholders' will to undertake new planting and replanting is taken for granted but this is only an assumption until some new land has been made available and his actual interest can be judged. This interest will no doubt be influenced by the general trend of the prices of rubber, food and other commodities in this country.

PROVISION OF PLANTING MATERIAL FOR SMALLHOLDERS

During 1946 steps were taken to revive the pre-war scheme for provision of budwood to smallholders from budwood nurseries developed with government assistance. No decision has yet been given on this proposal but during 1947 the Institute has collaborated with the Department of Agriculture to ensure, so far as possible, that sufficient supplies of budwood of the best clones are available at a nominal cost, to meet smallholders' needs. The Department has reconditioned the pre-war nursery areas on Agricultural Stations which survived the occupation years and the Botanical

Division of the Institute has provided the services of a skilled budding mandor to identify the clones in these nurseries. Considerable extension of the budwood nurseries has also been effected and budwood has been supplied from the R.R.I. Experiment Station to those which have reached buddable size.

Clones R.R.I.501, Tj.1, P.B.86, Pil.B.84, and Glen. 1 have been selected for supply to smallholders.

Up to the end of 1947 the supply of budwood available on Agricultural Stations was more than sufficient to meet the planting requirements of smallholders. The maximum possible areas of budwood nursery have however been maintained on the R.R.I. Experiment Station to meet any possible increase in demand by any state or district. It is now evident that in districts where replanting has proceeded most intensively the demand for budwood will exceed the local supply during 1948 and arrangements are being made to meet this need with budwood from the Experiment Station.

Plans for the provision of high-yielding planting material for smallholders have so far centred on the supply of cheap budwood of approved clones. This has been a matter of expediency since it has been relatively simple to expand the supply of budwood sufficiently rapidly to ensure that no area shall fail to have approved material for lack of sufficient supply. The merits of clonal seedlings as planting material for smallholders have not been overlooked. Clonal seedlings have practical advantages over buddings, particularly on holdings where the standard of early maintenance is lower than average, but only limited numbers of families of clonal seedlings have been tested which have produced yields comparable with the best budgrafts. Supplies of seed from such "proved" families are at present scarce and expensive. It is therefore essential that adequate supplies of proved clonal seed should be available before their use is widely recommended and encouraged. The common fallacy of attributing the high-yielding properties of the few proved families of clonal seedlings to all progeny of budgrafted trees is shared by many smallholders. There is however a greater danger of smallholders, with their limited means, being misled into the indiscriminate use of clonal seed unless our recommendations for their use are backed by a plentiful supply of the best material.

Inspection of seed can only indicate the mother-tree and to evaluate clonal seed it is necessary to have details of the area from which it originates. It is therefore essential to

control the source of supply in order to guarantee the quality of the seed. Since rubber trees will not produce seed in less than five years the development of special areas for seed production takes a long time. These points and the possibility of utilizing selected commercial plantings of bud-grafts as sources of seed are receiving consideration. During 1947 a small amount of clonal seed was made available to smallholders from the R.R.I. Experiment Station with the object of establishing representative areas on smallholdings which should provide useful information and serve as demonstrations in the future.

R.R.I. SMALLHOLDINGS

The small "museum" replanted block in the Ampang Road holding was opened for tapping in January on S/2, D/2. This block contains small plots of clones Tj.1, Tj.16, Av.49, Av.50, B.D.5, Pil.B.84, G.1, R.R.I.500, 501, 506, 513 and 514. The Chemical Division has obtained latex from this area for work on the creaming of different latices. The trees have also been utilized by the Botanical Division for investigations on the physiology of latex production, and the Pathological Division has found them useful for testing materials.

All the old seedling rubber in this holding had been felled during the Japanese occupation and it was decided that this vacant space should be developed as a budwood nursery which would serve as a small reserve against smallholders' needs. By the end of the year nearly two acres had been cleared and planted with young seedlings and about 700 budded stumps of clones Tj.1, Pil.B.84, R.R.I.501, 506 and 512 had also been planted. Growth has been excellent, and this nursery has been available for small-scale trials by the Soils and Pathological Divisions.

In the Ulu Klang holding little has been done beyond routine maintenance and tapping the old seedling rubber. Growth of the pre-war replantings has generally been well maintained and two small blocks will be ready for tapping in 1948 and a suitable experiment on smallholders' tapping methods will be set up. The old seedling rubber in the Ulu Klang holdings is now very poor and progressive replanting will have to be undertaken.

In view of the general usefulness of the Ampang Road holding to all sections of the Institute it is unfortunate that it has been impossible to secure an extension of the lease on this land which will pass out of our control early in 1948.

AGRICULTURAL SHOWS AND EXHIBITIONS

Rubber Instructors have been responsible for rubber-growing sections at State and District Agricultural Shows and have shown ingenuity in arranging their exhibits.

The R.R.I. section of the Malayan Agri-Horticultural Association Exhibition included exhibits from all Divisions. Items which appeared particularly appropriate to smallholders' present needs and interests were provided with labels in Romanised Malay. Rubber Instructors were on duty at all times to discuss rubber-growing problems and explain exhibits to interested smallholders.

An All-Malayan smallholders' rubber competition was included in the R.R.I. section. Entries, limited to ten per State, were submitted through State Agricultural Officers and usually included winning entries from District shows. The standard of cleanliness was high in all exhibits but common faults noted were oxidation and tackiness. Five first quality exhibits were awarded super-grade prizes and certificates.

ACKNOWLEDGMENT

The successful operation of the Smallholders' Advisory Service is dependent on the close co-operation of all sections of the Institute and on the collaboration of officers of the Department of Agriculture, and the writer is indebted to the many officers who have never failed to provide assistance in their various spheres.

IV. REPORT FOR THE YEAR 1948

Supervision and Organisation

No notable expansion of the Smallholders' Advisory Service has been possible during 1948, but the year may be regarded satisfactorily as one of consolidation after one of changes not only in organisation but in personnel. Incidence of leave was less heavy amongst Rubber Instructors than in previous years and the new recruits of 1947 settled down well in their districts. The influence exerted by Superintendent Rubber Instructors increased steadily during the year as these officers became familiar with their new appointments. The development of this scheme for local supervision of Rubber Instructors has proved its value during a year when administrative duties made heavy demands on the time of the senior officers available for the Smallholders' Advisory

Service. The field staff at the end of the year consisted of three Superintendent Rubber Instructors, 35 Rubber Instructors and 35 Rubber Demonstrators.

The new post of Assistant Smallholders' Advisory Officer was filled by the appointment of Mr. J. M. F. Greenwood who commenced duty on the 25th November.

The Smallholders' Advisory Officer (Mr. L. R. Davidson) went on long leave on the 5th July and his duties were taken over by Mr. E. G. B. Gooding of the Botanical Division who acted as Smallholders' Advisory Officer during the full period of leave which extended into 1949.

Visits to Rubber Instructors were necessarily limited by the high demands of office work during the second quarter in preparation for departure on leave. Early in the year, however, a fairly extensive tour in Perak, Province Wellesley and Kedah was undertaken and visits were also made to stations in Pahang, Negri Sembilan and Selangor. Twelve days were spent on these tours and nine Rubber Instructors were visited. Later in the year Mr. Gooding made visits of inspection to budwood and clonal seedling nurseries in Selangor, Negri Sembilan and Malacca.

During 1948 the Rubber Research Institute undertook to organise courses of training in rubber cultivation and production methods for young men about to enter the service of the Governments of British North Borneo and Sarawak. These men will be working amongst smallholder rubber growers in their own countries and their training was undertaken by the staffs of the Experiment Station and Smallholders' Advisory Service. The appointee of the Borneo Government, a holder of the Diploma of the College of Agriculture, received his training concurrently with a new Rubber Instructor. The six men from Sarawak had a special three-months period of training arranged for them on the completion of the one-year course at the College.

SUPERINTENDENT RUBBER INSTRUCTORS

The Superintendent Rubber Instructor for Perak was on long leave from January till May and resumed duty with Ipoh as headquarters instead of Taiping. This facilitates his work amongst Rubber Instructors and allows more satisfactory liaison with the the Department of Agriculture in Perak.

RUBBER INSTRUCTORS

Only one change has to be recorded in the complement of Rubber Instructors. This was the appointment in January of a new Malay Instructor who had recently obtained his diploma at the College of Agriculture. After a course of training at the Experiment Station and instruction with a senior Rubber Instructor he was posted to Pontian, Johore, in March. In January two new Instructors, one Chinese and one Indian had completed their training course and went to their first stations at Kluang and Kuala Lumpur respectively.

The last arrears of leave for Rubber Instructors were taken during the year and nine Instructors were absent for periods of one to five months during the year. The total leave amounted to 28 "Instructor months" or about six per cent. of Instructors' effective time. This is only a little higher than the normal and during the next two or three years no long leave will fall due for Rubber Instructors.

Only two transfers were effected during the year when the Indian Instructor formerly in Selangor went to Muar and a Malay Instructor was transferred from Ipoh to Taiping.

RUBBER DEMONSTRATORS

The development of our work in the different districts has been carefully studied and new Demonstrators have been appointed whenever it has seemed likely that the Rubber Instructors' effective area could be extended by having such assistance. The total number of Demonstrators increased from 28 to 35 during the year and further appointments will be required during 1949.

The Indian Demonstrator originally appointed in Selangor was transferred with the Rubber Instructor to Muar. Our first Chinese Rubber Demonstrator was appointed in October to work with the Chinese Rubber Instructor in Selangor.

A ten-days course of training was organised for Demonstrators at the Experiment Station in March but as accommodation was limited only six Demonstrators were able to attend. The course was supervised by a senior Malay Rubber Instructor and tuition and demonstration provided by the Experiment Station staff. The course covered tapping, disease control, budding and nursery work. Further training of Rubber Demonstrators is necessary and will be provided as facilities are available. Experience gained during the year on the distribution of planting material indicates that a sound

training in nursery practice will be very valuable to Demonstrators. An analysis of the distribution in 1948 of Rubber Instructors and Rubber Demonstrators is given in Table IV.

TRANSPORT

The majority of Rubber Instructors now have their own light cars and two special provisions have been made in an attempt to extend the Rubber Instructor's effective range in certain rather remote districts where roads are few and rough. In Pahang a boat with a nine horse-power outboard engine has been purchased for use on the Pahang river. The boat is used principally by the Rubber Instructor at Pekan but periodic trips to the Temerloh district are arranged and the work of the Rubber Instructors in these riverine areas has been greatly facilitated. A Willys Jeep has been provided for Trengganu where the Rubber Instructor has a very widely dispersed area of rubber holdings to look after and three Rubber Demonstrators to supervise. The roads and tracks of Trengganu are such as require a sturdy vehicle. Both the boat and the jeep have eliminated considerable wastage of time for the Rubber Instructors using them. These men were previously dependent on hired transport which was irregular and unreliable.

SMALLHOLDERS' RUBBER ADVISORY COMMITTEE

The normal meeting to consider estimates of expenditure for the following year was held in June because of the S.H.A.O's impending departure on leave and no other meeting took place during the year.

Many subjects were discussed including planting and planting material on smallholdings and co-operative marketing of rubber. Considerable interest was expressed in the replanting demonstration areas being planned on smallholdings.

Information on these and other subjects affecting rubber smallholders' interests was circulated to the committee as opportunity arose and the committee received copies of the quarterly reports of the Smallholders' Advisory Service.

Field Work and Advisory Policy

TAPPING

Smallholders' rubber production reached its peak since the reoccupation of the country during the first six months of

TABLE IV *Distribution of Field Staff at 31st December 1948*

State or Territory	Areas of Rubber* Smallholdings	Superintendent Rubber Instructors	Instructors				Demonstrators	Average acreage per Rubber Instructor (to nearest thousand)
			Malay	Chinese	Indian	Total		
Selangor	160,702	1	3	1	1	5	5	32,000
Negri Sembilan	117,453		2	1	1	4	2	29,000
Malacca	90,876		1	1	—	2	1	45,000
Perak	268,292	1	4	2	1	7	5	38,000
Johore	405,643	1	3	3	1	7	6	51,000
Pahang	87,969		3	—	—	3	5	29,000
Kedah/Perlis	141,899		3	—	—	3	3	47,000
Penang and P. Wellesley	32,027	—	—	1	—	1	1	32,000
Kelantan	77,648		1	—	—	1	3	78,000
Trengganu	27,669		1	—	—	1	3	28,000
Leave	1,410,178	3	21	9	4	34	34	—
Experiment Station	..	—	—	—	—	—	—	—
..	..	—	—	1	—	1	—	—
Total	..	3	21	10	4	35	34	—

* Figures taken from the Rubber Statistics Handbook 1948

1948. In the third quarter a high level of production was maintained though some reduction compared with the preceding two quarters was apparent; thereafter the decline was more marked. It is probable that several factors have contributed to this trend. The "flush" yields following the rest of all rubber areas during the Japanese occupation must be reckoned as a temporary phase. The duration of such improved yields could only be guessed at but for the country as a whole it would depend on such factors as intensity of tapping and the time required to bring all areas into production. It is possible that 1948 saw the return to normal yields of smallholders' rubber, and if this is so it would tend to exaggerate any tendency to lower production. Smallholders' production has always been sensitive to price changes and the drop in production in the final quarter coincides with a fall in price. The emergency conditions in the country have also had their effect on the decline in production. On family holdings of under 25 acres the reduction has probably been in tapping efficiency rather than in area tapped; the enrolment of large numbers of able-bodied men from the kampongs as Special Constables has reduced the quality of the tapping since the work has to be done by the less capable members of the family. A further effect of the unsettled state of the country is the loss of production from many of the medium type of holdings. Where these are in remote areas and the owner lives away from his land he is frequently unwilling to visit his possessions. Tapping for the owner may be discontinued rather than allow it to proceed in the absence of adequate supervision.

COAGULANTS

Supplies of sulphuric acid coagulants have remained plentiful throughout the year and have filled the major part of smallholders' requirements. The supply of formic and acetic acids gradually became easier but there was little attraction for smallholders in the more expensive coagulants which are not normally sold conveniently in bottles nor from the dealers' shops which will provide credit.

In the middle of the year it was decided to discontinue the service whereby Rubber Instructors distributed to smallholders the limited amounts of formic acid made available through the Department of Agriculture. This work was appreciated only by a small minority of smallholders and took up a disproportionate amount of Rubber Instructors' time. Its discontinuance has not materially affected the proportions

of the different acids used, which will be determined by price, convenience of supply and credit facilities. Rubber Instructors still help groups of smallholders who wish to use approved acids to obtain the necessary bulk supplies.

PREPARATION AND MARKETING

In several districts, notably in Northern Perak, schemes whereby licensed rubber dealers must display boards showing samples of the different grades and current prices, have been introduced by the local authorities. The object of these schemes is to enable the smallholder to obtain a fair price for his product. That the smallholder does not in fact get so much benefit as might be expected is due, in part, to his inability to smoke his sheet. Unsmoked sheet is a difficult commodity to grade and only by smoking can the full premium for good quality be obtained. The unsmoked sheet allows greater profit to the middleman and it is therefore unlikely that dealers will co-operate in a scheme designed to reduce some of their profits. Grading schemes to be completely successful require special inspectoral staffs to check dealers' practices and enforce the conditions of the scheme. The system operated in Ceylon, where buying depots in different parts of the country under the Commissioner for Rubber buy smallholders' rubber only if it is smoked, has much to recommend it as a means of improving quality. Payment of the full value for the smoked rubber provides sufficient incentive to encourage the smoking of rubber and the competition from a few well-placed government buying depots ensures a fair price from the dealers.

During the year the development of an experimental scheme for the purchase of liquid latex from smallholders was carefully observed by our Rubber Instructor at Sungei Patani who assisted both the organisers, Malayan American Plantations Ltd., and the smallholders in an endeavour to ensure that the venture was a success. The price paid for latex under the scheme was approximately 5 cents per pound of dry rubber (which included duty) below the current Singapore price for R.S.S. 1. The price was attractive to smallholders who appreciated this outlet for their latex and amounts offered rose rapidly from five gallons on the first day to 50 gallons after a month, and thereafter steadily increased to a maximum of over 350 gallons in October.

Response to the advice of the Rubber Instructor was good and latex production in the district improved in cleanliness. Results of laboratory tests by the purchasers showed that

the latex had a very low strainability which was considered to render it unsuitable for the production of latex concentrates, and towards the end of the year they expressed their intention to cease purchasing from smallholders. This decision was no doubt also dependent on the unsuitability of the standard transportation equipment for collecting latex from smallholders and on the general fall in the world demand for latex concentrates. On representations from the R.R.I., however, Malayan American Plantations Ltd. agreed to continue their purchases in the district until a suitable alternative scheme for the purchase of latex and manufacture of first quality sheet could be organised by the Rubber Research Institute. This was planned to come into operation by the end of February 1949, and an interesting new line of investigation into the problem of improving the smallholders' rubber has thus been opened up.

This will not be an isolated case since other similar developments have been reported from Trengganu, where two or three individuals are now purchasing latex for the manufacture of sheet rubber. These and all similar efforts will be carefully watched and assisted as much as possible, but smallholders should realise that the full benefits of improved quality will not be wholly theirs unless they combine in groups to obtain the necessary equipment and so obtain all possible advantages from a suitably organised joint effort. The larger scale of operations under central manufacture makes possible the use of equipment and technique denied to the small-scale operator, and can readily secure considerable improvement in quality.

CO-OPERATIVE SMOKE-HOUSES

In the 1947 annual report reference was made to plans to investigate the possibilities of encouraging the smoking of rubber by smallholders who could be persuaded to form co-operative groups. The State Agricultural Officer for Selangor and the Co-operative Marketing Officer, have collaborated with us in planning the methods to be employed, the assistance to be provided and in the selection of possible sites.

Smoke-houses with inexpensive temporary fabrics of bamboo and gunny were designed and all materials which had to be purchased were provided by the Department of Agriculture. Difficulties were encountered in developing sufficient enthusiasm amongst smallholders for them to undertake co-operatively the work necessary to obtain the locally available materials and to erect the smoke-houses. Assistance

from Rubber Demonstrators as well as practical instruction by the Rubber Instructors was necessary before a building could be completed.

The completion of a building did not however necessarily result in the commencement of smoking operations and the dependence of smallholding communities on the rubber dealers was revealed. Rubber is so commonly pledged before produced, against food and other requirements, that the man in debt must continue to deal with his creditors or his supplies will be cut off. Even when not actually in debt Malay smallholders seldom seem to be able or willing to wait the five or six days necessary for smoking before selling their rubber. The unfavourable effect of a successful co-operative manufacturing and marketing society on the trade of the middle-man is fully understood by the rubber dealers and their passive and active resistance to any scheme for co-operation is to be expected.

Three smoke-houses were completed in Selangor under the advice of Rubber Instructors and with the assistance of the Department of Agriculture. Only one of these operated successfully. In the other two cases dissension amongst the smallholders and no doubt the influence of local vested interests effectively prevented the smoking of rubber. The one smoke-house at Sungei Chinchin was in action during the last six months of the year. It produced a large proportion of grades 1 and 2 rubber and provided a useful profit to participants. In spite of the obvious benefits of the project to the smallholders, this smoke-house never operated to capacity although the rubber production of the district would have been more than sufficient for this. This is because the weaker members of the community were never able to disentangle themselves from the demands of their creditors. For the same reason it never proved possible to initiate the registered co-operative marketing society which the Co-operative Marketing Officer hoped for. Had this eventuated it would have made possible the insurance of the smoke-house and its contents.

Old established co-operative societies for the manufacture, smoking and marketing of rubber, though few in number, appear to have no difficulty in maintaining operations to the benefit not only of their members but of all smallholders in the district who share in the fruits of a society's successful competition with the dealers.

A successful venture of recent origin has grown up with the organisation of the Young Farmers Club at Klang, which is perhaps a lesson to other parts of the country that youth must be called on to take a leading part when innovations are required. The rubber producing section of this organisation has been anxious to avail itself of the advice of the Rubber Instructor in the district.

DISEASES AND PESTS

Rubber Instructors have continued their efforts in the difficult task of educating the smallholders on the need for energetic action in the control of mouldy rot. It is not easy to make smallholders appreciate the importance of regular and careful treatment. Discouragement by the ineffectiveness of previous half-hearted attempts to obtain control of the disease has in many cases to be overcome before advice will be followed. Smallholders have frequently been found to have a prejudice in favour of one of the more expensive fungicides and our advice has been that choice from the approved list of fungicides should be made on the basis of cost of treatment.

Towards the end of the year an outbreak of mouldy rot was reported from northern Kedah and Perlis, an area which had previously had the reputation of being free from the disease.

The control of pink disease is likely to be a matter of increasing importance to smallholders who are planting young rubber, and materials are being supplied to Rubber Instructors wherever necessary so that proper methods of treatment can be demonstrated.

Other diseases and pests have received attention as required. The general problems regarding control on smallholdings have not altered materially in the last twelve months and there is therefore little to add to the 1947 report on this subject.

AGRONOMIC PROBLEMS

Probably the most serious cause of loss to the rubber growers and the most expensive trouble to combat is the encroachment of lalang onto rubber land. To dig out lalang is a laborious process and occupies unremunerative time which the smallholder cannot afford. Less labour is required in spraying with sodium arsenite but the necessary outlay on equipment and material is high. Many smallholders however have been anxious to use sodium arsenite for lalang eradication,

and Rubber Instructors have spent much time in demonstrating methods and giving assistance. This is very necessary on smallholdings since the owners are unlikely to appreciate fully the possible danger to men and animals if sodium arsenite is used without proper precautions. They can however be taught to use the chemical with care and it is desirable that they should not be denied the opportunity of using what is the least expensive method at present known of controlling lalang. Good results have been obtained with sodium arsenite in young pre-war replantings where the immediate improvement to the rubber tree foliage provides an effective check to the regeneration of the lalang. The effect has not been so striking in areas which have been felled and reverted to lalang during the occupation. In the absence of overhead shade or leafy ground cover the lalang shows great persistence in recovery even after many sprayings. Where the fertility of the land and the absence of slope allow it the most economic method of reconditioning such areas on smallholdings would seem to be by the cultivation of vegetable crops. This is often done by Chinese smallholders who plant rubber trees after the land is in production with food crops.

Where land requires drainage the smallholder is frequently confronted with the difficulty of securing a drainage outlet. A smallholder can rarely secure the deepening of his existing drainage system or the introduction of a new system without the co-operation of his neighbours through whose land the drainage water must flow. In certain of the coastal areas of the country and especially in Johore the drainage needs of large communities are dependent on tidal outlets and main drains which are the responsibility of Government Departments. The damage done by years of neglect during the occupation have not yet been made good, with the result that many areas suffer from inadequate drainage and old rubber has deteriorated from water-logging. Attempts to replant such areas are likely to produce disappointing results unless drainage improvement proceeds at the same time.

PLANTING OF RUBBER

Table V shows the amount of planting and replanting which has taken place throughout the country since 1945 directly observed by Rubber Instructors. The figures do not claim to be complete but can be taken as a minimum of the extension of the area of young rubber on smallholdings.

In round figures the total amount of young rubber planted since the re-occupation of the country is 8,000 acres. This

TABLE V. Rubber Planting on Smallholdings (under 100 acres) since September 1945

State or Territory	* Area of smallholding rubber (under 100 acres)	* Area of smallholding rubber felled during the occupation	Replanting 1948		Replanting since 1945		New Planting	
			Felled 1942/45	Felled since 1945	Felled 1942/45	Felled since 1945	1949	since 1945
	acres	acres	acres	acres	acres	acres	acres	acres
Selangor	160,702	2,388	114	257	1,176	395	307	369
Negri Sembilan	117,453	1,327	70	131	85	245	462	462
Malacca	90,876	6,021	273	—	503	12	482	482
Perak	268,292	1,071	244	75	471	150	7	7
Johore	405,643	8,966	63	13	2,002	38	69	129
Pahang	87,969	218	2	24	13	39	392	392
Kedah and Perlis	141,899	2,179	27	68	153	98	35	35
Penang and P. Wellesley	32,027	3,095	519	54	666	54	26	26
Kelantan	77,648	3,066	8	—	8	—	77	77
Trengganu	27,669	7	—	—	—	—	57	57
Total	1,410,178	28,338	1,320	622	5,077	1,031	1,914	2,036

* Figures taken from Rubber Statistics Handbook 1948

is made up of 5,000 acres replanted on areas felled during the occupation, 1,000 acres replanted where the old rubber trees have been removed since 1945, and 2,000 acres of new planting. These figures do not take any account of the large acreages of illegal new planting which have taken place in various parts of the country both during and since the occupation. If steps could quickly be taken for the proper alienation of such land the area of improved young rubber in the hands of smallholders would receive a large addition and steps could be taken to secure the establishment of approved material in areas which may otherwise remain as inferior rubber belonging to no-one.

That only one-sixth of the rubber smallholdings on which the rubber trees were felled during the Japanese occupation has so far been replanted appears a disappointing indication of smallholders' interest in securing improved rubber trees. It is significant that the rate of replanting of these areas has slowed down considerably during 1948 and it appears likely that under present conditions much of the balance will remain unplanted.

Probably the main factor which has prevented more extensive replanting of Japanese-felled rubber lands has been the dense growth of lalang on much of the land. Satisfactory growth of rubber cannot be obtained unless the lalang is eradicated and this is a laborious undertaking and one which a man who has to work for the immediate subsistence needs of his family cannot attempt. Some of the areas of rubber felled during the occupation years had never been economic producers owing to unsuitable soil conditions or to a previous history of land exploitation. The selection of such areas for felling shows creditable forethought on the part of those who had to put into effect Japanese orders on this subject. It is perhaps not surprising at a time when there is some doubt as to the future of the rubber plantation industry if they are not again planted with rubber. Other rubber trees were felled during the occupation years on coastal land affected by the prolonged neglect of drainage requirements, and here again replanting cannot be expected until the drainage has been set right.

Only a relatively small amount of rubber has been cut out for replanting and this generally by owners who have other sources of income than their rubber trees. Such replanting has been done only where it has been inexpensive or even profitable to dispose of the old rubber trees as firewood.

The year 1948 has seen the commencement of new planting by smallholders. Less than 600 acres of the 1,900 acres planted has been on land for which a pre-war title was held and with the exception of Pahang there are nowhere any considerable areas of unplanted land in smallholders' possession. Extension of new planting on smallholdings will therefore in most districts be limited by the speed with which land alienations are made until some part of the existing demand for land has been satisfied.

PROVISION OF PLANTING MATERIAL FOR SMALLHOLDERS

A scheme for the supply of planting material for smallholders conceived broadly on the lines which received official approval in 1940 has been undertaken by the Department of Agriculture and the Rubber Research Institute. It is hoped that this scheme will be financed from Colonial Development and Welfare Funds but pending a decision on this matter the Rubber Research Institute and the Department of Agriculture have taken steps to supply immediate requirements of planting material from reconditioned and extended budwood nurseries.

Plans for the provision of planting material differ in one important respect from those which were coming into operation in 1941. It is now proposed that provision will be made for the supply of approved clonal seedling material as well as budwood of the best proved clones. Smallholders will have the choice within the limits of available supplies between the two types of planting material but as a safeguard against unskilled handling of seed which might result in heavy casualties and in the seed which failed to germinate being replaced by inferior substitutes, smallholders will receive clonal seedling material only as clonal seedling stumps which will be grown on the nurseries of the Department of Agriculture and the R.R.I. Experiment Station for about nine months before sale. The production of clonal seedlings requires much more extensive nurseries than budwood and preparation must be made a year in advance of requirements.

Anticipating approval for the scheme and in order that some clonal seedling material should be available at as early a date as possible a start was made on the planting of clonal seedling nurseries in 1948. The nurseries were developed on Agricultural Stations and on the special area at Sungei Buloh set aside for the provision of planting material for smallholders, and necessary finance for the project was obtained by a grant from the Malayan Rubber Fund.

The development of these nurseries required the collection from selected commercial plantings of good approved clonal

seed and distribution to the various stations. This work was under the charge of Mr. Burkill of the Botanical Division and his report covers the development of the organisation.

During the year, and more particularly during the first six months of the year, budwood was supplied by the R.R.I. Experiment Station to complete the budding of Agricultural Department budwood nurseries. Budwood of all the five clones approved for use on smallholdings was supplied according to the requirements of the different stations, but of greatest importance were the supplies of R.R.I. 501 which had not been previously multiplied on Agricultural Station nurseries. Another new clone for smallholders is Glenshiel 1 which is considered to fill the particular requirements of the coastal alluvial soils.

Supplies of planting material to smallholders during 1948 inevitably took the form of budwood from established nurseries. The Agricultural Station nurseries were in general able to meet local requirements fully but where local supplies were not sufficient to meet heavy demands the full quantity was made up by budwood from the R.R.I. Experiment Station. This was necessary early in the year in North Johore and Malacca. In order that budwood could be delivered with the greatest economy full truck loads had to be taken on each occasion and the rapid distribution and use of such large quantities of budwood entailed heavy work for the Rubber Instructors and Demonstrators in those districts during the five or six days when the budwood might be expected to remain in good condition. A total of 4,490 yards of budwood was supplied to North Johore on three separate occasions and to Malacca 1,400 yards in two deliveries.

The extent of budgrafting in areas under the supervision of Rubber Instructors during 1948 is shown in the following table:—

State or Territory	Area Budgrafted during the year
	acres
Selangor ..	147
Negri Sembilan ..	65
Malacca ..	445
Perak ..	57
Johore ..	450
Pahang ..	7
Kedah and Perlis ..	33
Penang and P. Wellesley	158
Kelantan ..	2
Trengganu ..	—
Total ..	1,364

This budgrafting represents much hard work on the part of Rubber Instructors and Demonstrators in the districts where it has proceeded most intensively. There is still much ground to be covered in the areas recorded as planted by the end of 1947, and an increase in the amount of planting is always anticipated. Full use however has been made of the budgrafting which has been done to extend the knowledge of the art amongst the smallholder community and there should be steadily increasing numbers of people in the kampongs who are competent to undertake budding in future.

REPLANTING DEMONSTRATIONS ON SMALLHOLDINGS

Since 1945 replanting on smallholdings has proceeded relatively intensively in certain districts, whereas in other parts of the country there is no interest in the practice. Notable areas of extensive development of replantings are Malacca and North and West Johore, while in contrast the Malay smallholders in districts of Perak appear to take little interest and little replanting has been done.

This varying interest in replanting might be due to economic factors such as age and condition of the old trees, ability to grow and market vegetable crops interplanted with the young rubber or to a profitable market for rubber wood, but it is not considered that such reasons can provide a complete explanation. A certain lethargy has to be overcome and it therefore seems desirable to establish examples of successful replanting on smallholdings in areas where interest in replanting has been slight.

The selection, establishment and maintenance of such demonstrations present certain difficulties and the best prospect of overcoming these lies in careful preliminary investigation of the holding and the owners' capability. Nine areas were selected about the middle of 1948 and the work of establishing these with different types of planting material proceeded during the second half of the year. The experience obtained on these will be useful in the selection of future areas.

It does not seem desirable nor to serve the objects of the demonstrations if they are established on land belonging to individuals of more than average means. Neither does complete financing of the work of replanting show the ordinary smallholder that replanting is within his capabilities. The typical working smallholder who is himself willing to undertake the essential work of replanting has been sought, and assistance has been confined to the supply of planting material

and essential materials which have to be purchased, such as fertilizers. Assistance is also given with budding and with the more elaborate refinements of planting practice which the smallholder would not normally undertake. Examples of these are terracing on sloping land or isolation trenching to limit root competition from surrounding old rubber trees.

R.R.I. SMALLHOLDINGS

Tapping of the young rubber trees and maintenance of the nursery area on the land opposite the Institute continued during the first six months of the year. When building operations were commenced thereafter, seedling material was transferred to the Experiment Station and young budded plants to the smallholdings at Ulu Klang. Our interest in the Ampang Road area became limited to the experimental tapping of certain selected trees.

On the Ulu Klang holding young replanted rubber of clones Tj.1 and Pil.B.84 was opened for tapping in April. This area is being used by the Botanical Division for a tapping experiment to compare half-spiral alternate-daily with third-spiral daily tapping. The latter is limited to approximately 25 tapping days a month by not tapping on Sundays and holidays.

A small area of three-quarters of an acre was prepared for replanting on the hedge-planting system. The old rubber rows were sixteen feet apart and every fourth row was felled and the stumps removed. Replanting was carried out along the line of the felled rows of rubber trees. Two "hedges" were planted with germinated seed in a double row three feet between the two component rows and three feet between plants along the rows but the planting points were staggered in the two rows. For the other two "hedges" the interval between double rows and planting points was four feet.

We have thus obtained four "hedges" at 64-foot intervals with three rows of old rubber trees standing, and in tapping, between each pair of "hedges". The young plants in the hedges are protected from root competition from the old rubber trees by isolation trenches on each side of and ten feet away from the centre line of each "hedge".

The old rubber will gradually be eliminated as it is shown to interfere with the growth of the young rubber trees. Our object is to discover what proportion of the old rubber stand can be kept in tapping after replanting and for how long. The area under this system of hedge-planting will be extended during 1949, and other modifications in practice will be tried.

AGRICULTURAL SHOWS AND EXHIBITIONS

Superintendent Rubber Instructors and Rubber Instructors organised exhibits for State and District Agricultural Shows, and prizes were given by the Institute for all rubber competitions at such shows.

Preparations were well advanced for an exhibit of interest to smallholders at the annual Malayan Agri-Horticultural Association Exhibition. When this event was cancelled the arrangements for the smallholders' smoked rubber competition were continued and entries were received and judged at the Rubber Research Institute.

ACKNOWLEDGMENT

Much of what is recorded in this report took place while Mr. E. G. B. Gooding was Acting Smallholders' Advisory Officer and the writer is indebted to Mr. Gooding for his work during this period.

Our thanks are, as always, due to the Officers of the Department of Agriculture who continue to take a lively interest in our work in all parts of the country and whose assistance and guidance is a valued help to Rubber Instructors.

L. R. DAVIDSON,
Smallholders' Advisory Officer

KUALA LUMPUR
26th May, 1949

THE RUBBER RESEARCH INSTITUTE OF MALAYA

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Edited by C. E. T. Mann on behalf of the Board of the
Rubber Research Institute of Malaya.